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The PROGRESSIVE FISH-CULTURIST

Vol. 13 No. 3

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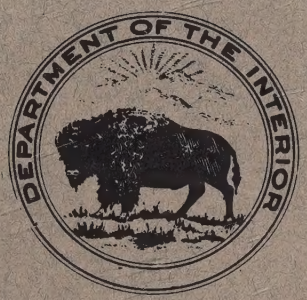

JULY 1951

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

THE PROGRESSIVE FISH-CULTURIST

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(See inside back cover)

The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

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DELAY OF SPAWNING IN EASTERN BROOK TROUT BY MEANS OF ARTIFICIALLY PROLONGED LIGHT INTERVALS

AN ATTEMPT TO DECREASE LOSSES AMONG HOLD-OVER STOCK DURING NORMAL FALL SPAWNING SEASON

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AT THE Harrietta Hatchery, a facility of the Michigan Department of Conservation located in Wexford County, Michigan, a serious problem has been developing in recent years. Eighteen-month-old eastern brook trout (Salvelinus fontinalis), when held over the winter for stocking during the following year, have been subject to excessive fungus infections and high losses during the normal fall spawning season. Frequent treatment with oxalate crystals of malachite green (zinc free) helped to control heavy losses but failed to prevent them. As the development of fungus followed injuries sustained in vigorous spawning activity, which is, of course, foredoomed to failure when occurring in hatchery ponds, suppression of the reproductive urge appeared to be a possible solution to the problem.

It is now well known that sexual cycles of animals can be modified by the use of certain hormones and by artificially changing the normal daylight interval. Hasler, Meyer, and Field (1939) induced premature spawning in rainbow trout (Salmo gairdnerii) and in brown trout (S. fario) by the use of pituitary glands of carp. Bissonnette (1930, 1932, 1933, 1935, 1936), Bassett (1946), and others have demonstrated that the normal gradual change in daylight interval is an important factor in sexual cycles of certain birds and mammals, and that the cycles can be modified by manipulations of the daylight interval by artificial means. Hoover and Hubbard (1937) induced eastern brook trout to spawn from 1 to 4 months earlier than normal by artificially shortening the normal daylight interval and maintaining a constant water temperature.

To date, the reported experiments involving modification of the time of spawning in fish have been designed to accelerate, rather than to retard, the process. The present study was based on the theory that by keeping light on the fish for a constant length of time every day and preventing the gradual shortening of the normal daylight interval prior to and during the spawning season, the spawning urge could be inhibited or at least retarded enough to prevent fighting and injury among the fish.

MATERIALS AND METHODS

Two hatchery ponds (Nos. 14 and 18), of comparable size and having similar histories as to rearing of trout, were chosen for the experiment. One group of 18-month-old eastern brook trout was divided equally between these ponds. From

Contribution from the Michigan Institute for Fisheries Research.

August 15 through December 31, 1948, Pond No. 18 was illuminated by electric lights every day from 5 to 8 a.m. and from 5 to 10 p.m. Over this pond (figures 1 and 2), which is 90 feet long and 30 feet wide, four 100-watt and two 200-watt electric-light bulbs were strung in a straight line, evenly spaced and suspended 7 feet above the water. The 200-watt bulbs were placed at each end of the series. Pond No. 14 was not artificially illuminated; it served as a control pond.

Thirty specimens of what were believed to be male fish were collected from each pond every 2 weeks during the study. Owing to the difficulty of distinguishing between unripe male and female fish, the samples usually did not contain exactly the desired number of males. All specimens were preserved in 10-percent formalin and were examined 1 week after collection.

Dr. O. H. Robertson, then with the Department of Medicine, University of Chicago, and currently with the Department of Biology, Stanford University, kindly offered to study the thyroid glands in a search for possible correlation of the effects of prolonged light with structural modification of the gland. Thyroids were removed from specimens of each group collected and preserved in Bouin's fluid. Dr. Robertson reported, however, that any differences that might have been present were obscured by a very marked hyperplasia resulting from lack of sufficient iodine in the diet.

The experiment was first attempted in the fall of 1947 and resulted in the suppression of trout spawning in the lighted pond for several weeks although the pond was poorly lighted and the lights were not turned on until September 12. It was impossible to demonstrate any difference in loss between the lighted group and the controls because very little fungus developed on fish in any of the ponds during the fall of that year. In the first experiment, the weights of both testes and ovaries were used as an index of ripeness of the fish. As both sexes gave equivalent data, however, it was apparent that examination of one sex was sufficient to give an adequate index and only the testes were weighed in the present study.

Clarence L. Schloemer, in his study (1947) of the reproduction cycles of five species of Texan centrarchids, used the formula:

$$\text{ovary weight} / \text{body weight} \times 10^3$$

to obtain a factor of gonadal development. This formula was modified for use here. As a measure of the effects of artificial illumination, the testes of both groups of fish were weighed in grams and body length in millimeters was substituted for body weight in the formula. Body length was used because visits to the hatchery were not always made at the same hour, so that some collections were made after the fish had been fed and others were made before feeding: consequently, the comparative weights would have varied from one collection to another, depending on when the collections were made and on the appetite of the individual fish. The cube of the body length was used to give an expression of length that would be closely related to body weight, because as length increases, weight increases approximately by the cube. The formula then becomes:

$$X = \text{weight of testes} / \text{body length}^3$$

$$X = \frac{\text{Wt. T}}{L^3}.$$

RESULTS

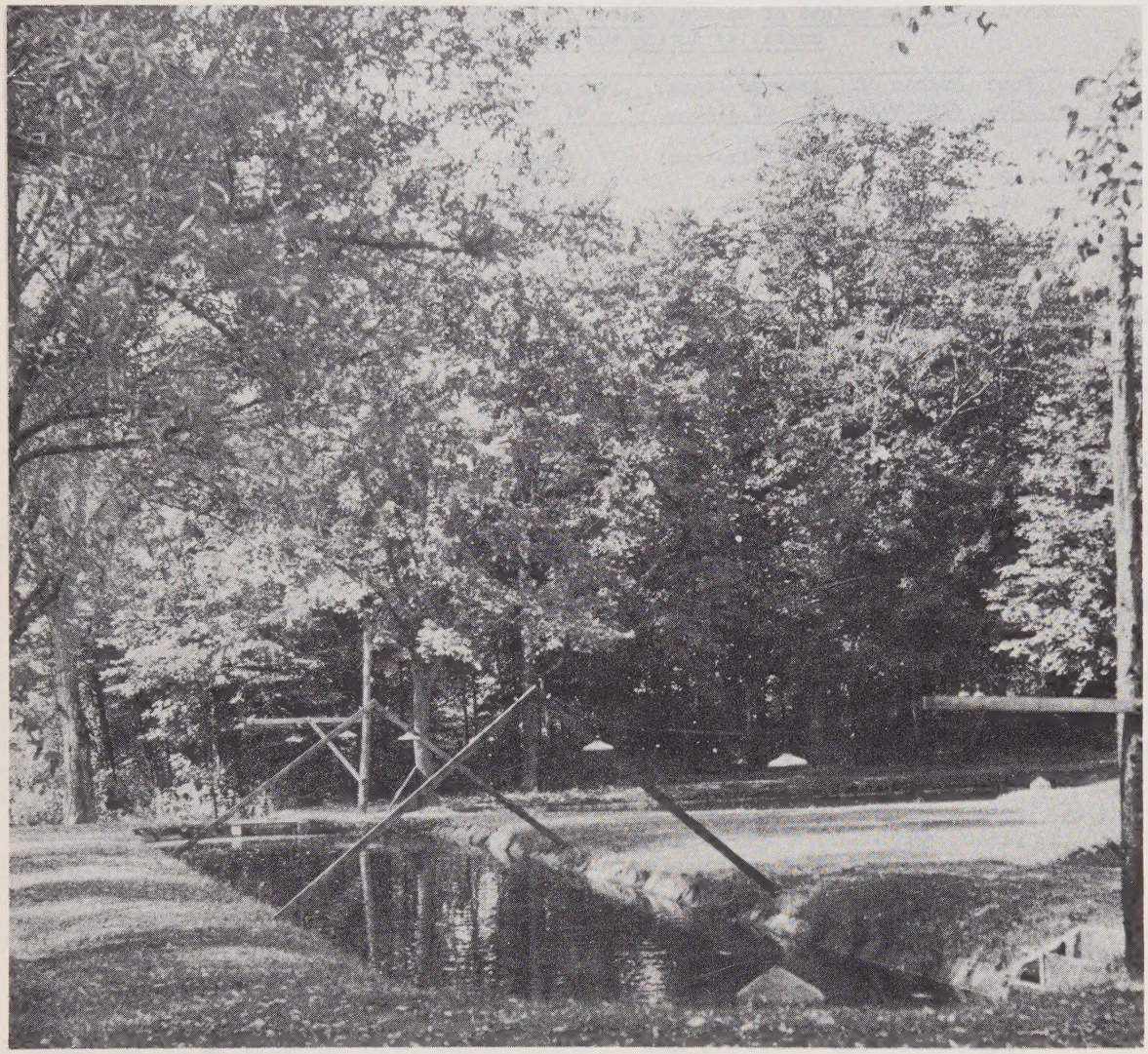
Table 1 presents the data obtained and includes the percentage of loss in the ponds during each 2-week period. A curve (figure 3) of the factor Wt. T/L^3 for the two groups demonstrates that the fish in Pond No. 18 (lighted) retained a higher factor of gonadal development for a longer period of time than those in Pond No. 14 (control). The curve indicates that some spawning occurred in

(Opposite page)

FIGURE 1.--Arrangement of lights over pond containing eastern brook trout.

FIGURE 2.--Lighted pond at night.

(Photographs courtesy the author)



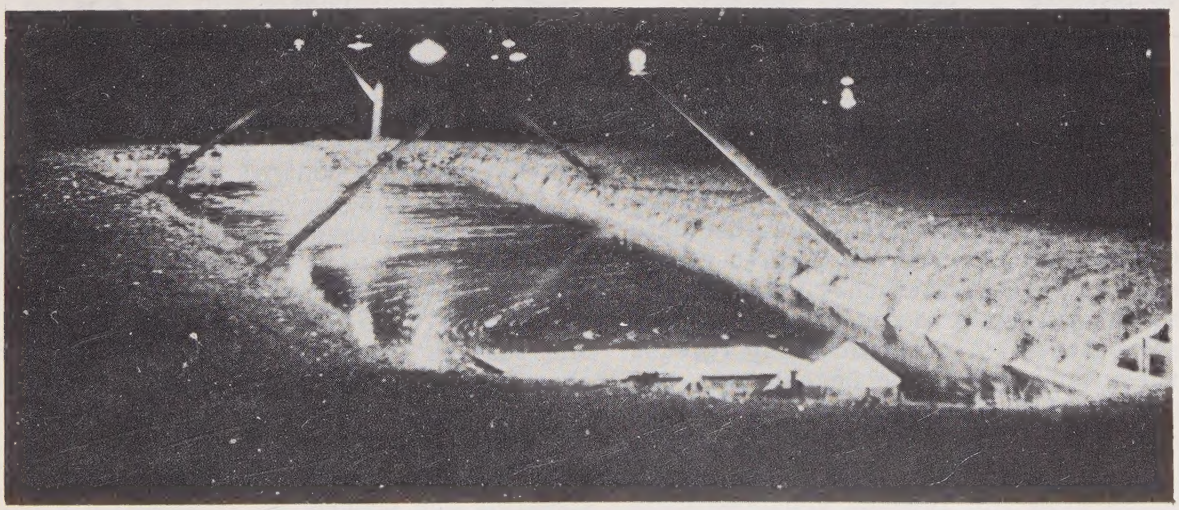


TABLE 1.--Average weight of testes, factor for gonadal development, and percentage of mortality during the experimental period

Date	Pond No.	Number of specimens	Average length of fish	Average weight of testes	Factor for gonadal development[1/]	Percentage of mortality
			(millimeters)	(grams)		
9/ 7/48	18	25	180.8	2.70	45.69	0.32
	14	14	183.0	2.90	47.32	.021
9/21/48	18	10	156.3	1.34	35.09	.19
	14	13	145.5	1.26	40.91	.085
10/ 5/48	18	20	186.4	3.09	47.72	.88
	14	12	172.4	2.11	41.18	.24
10/19/48	18	27	200.4	3.61	44.89	.50
	14	31	191.8	2.31	32.74	.14
11/ 3/48	18	30	198.7	3.88	49.46	.39
	14	29	192.0	1.88	26.56	.09
11/16/48	18	28	200.1	3.08	38.44	.60
	14	28	187.3	1.98	29.93	2.12
12/ 1/48	18	30	199.4	2.64	31.53	1.19
	14	29	185.6	1.92	30.03	9.35
12/13/48	18	30	206.1	2.76	31.53	2.52
	14	28	195.8	1.40	18.65	4.93
12/28/48	18	26	201.6	2.41	29.41	6.14
	14	26	191.0	1.26	18.08	7.95
1/11/49	18	29	205.8	2.50	28.68	7.06
	14	32	193.3	1.36	18.82	3.90
1/26/49	18	28	217.8	2.49	24.10	12.40
	14	27	201.6	1.08	13.18	2.83
2/ 8/49	18	27	209.1	1.97	21.55	8.17
	14	31	195.8	0.56	7.46	1.38
2/17/49	18		No collection made			2.80
	14					.95
3/ 1/49	18	30	209.6	1.82	19.78	2.18
	14	25	207.8	.50	5.57	.90

[1/] $\frac{\text{Wt. T}}{L^3 \times 10^{-6}}$

the control group between October 5 and November 5, and again between November 3 and November 16, but gonadal products were released slowly from the latter date until January 11. For the lighted group, the curve demonstrates only a slight release of gonadal products between October 5 and October 19, a considerable release between November 3 and December 1, and a slow release between the latter date and March 1. Even at the termination of the experiment on March 1, the testes of fish from the lighted group weighed more than three times as much as those of fish from the control group.

Although the curve of the factor of gonadal development demonstrates that the release of milt was retarded in the lighted group, the curve is disappointing in that it does not show very clearly the peak of spawning activity. Daily observation of the fish by hatchery personnel indicated that there was a direct correlation between heightened spawning activity and greater fish mortality. A graph of the percentage of loss in each

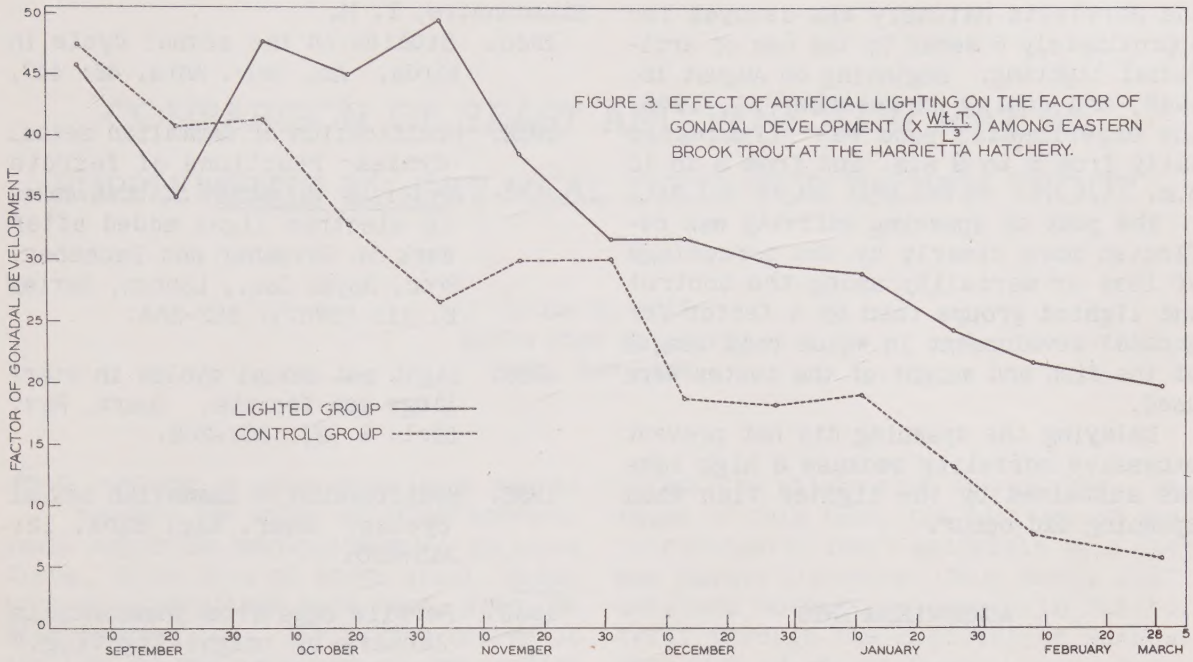


FIGURE 3. EFFECT OF ARTIFICIAL LIGHTING ON THE FACTOR OF GONADAL DEVELOPMENT $\left(\times \frac{Wt.T.}{L^3}\right)$ AMONG EASTERN BROOK TROUT AT THE HARRIETTA HATCHERY.

group (figure 4) shows a definite peak in the control group for the period of November 16 to December 1, a reduction for the December 2-13 period, and another peak for the December 14-28 period. Owing to a misunderstanding, the control group was treated with malachite green early in December, and this undoubtedly accounts for the reduction in the percentage of loss for the December 2-13 period. It is therefore impossible to determine the exact period of greatest spawning activity in the control group. The sharp rise during the preceding period, however, would indicate that the peak probably occurred between December 2 and December 13. No treatment was administered to the lighted group; so its graph can be considered a reliable index of spawning activity. The peak percentage of loss in this group did not occur until the period January 11-26, approximately 6 weeks later than among the control fish.

CONCLUSIONS

Spawning among eastern brook trout at

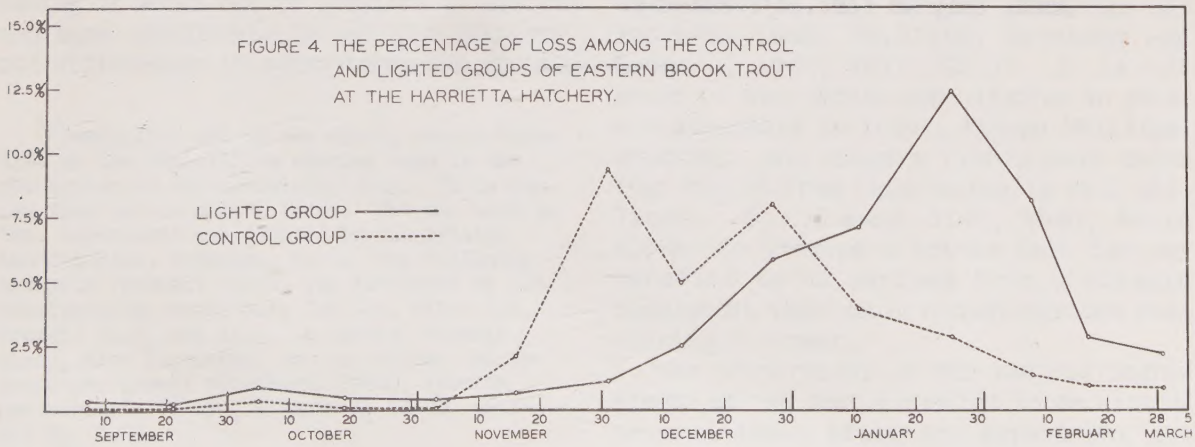


FIGURE 4. THE PERCENTAGE OF LOSS AMONG THE CONTROL AND LIGHTED GROUPS OF EASTERN BROOK TROUT AT THE HARRIETTA HATCHERY.

the Harrietta Hatchery was delayed for approximately 6 weeks by the use of artificial lighting. Beginning on August 15, 1948, and ending on December 31, 1948, the experimental pond was illuminated daily from 5 to 8 a.m. and from 5 to 10 p.m.

The peak of spawning activity was reflected more clearly by the percentage of loss or mortality among the control and lighted groups than by a factor for gonadal development in which body length of the fish and weight of the testes were used.

Delaying the spawning did not prevent excessive mortality because a high loss was sustained by the lighted fish when spawning did occur.

ACKNOWLEDGMENTS

The fine cooperation of the staff of the Harrietta Hatchery, particularly of Louis Root, foreman, and Ed Basford, superintendent, is gratefully acknowledged. Thanks are also due to Dr. Ralph Hile of the U. S. Fish and Wildlife Service and to Dr. Justin W. Leonard of the Institute for Fisheries Research for invaluable advice concerning statistics and preparation of the manuscript.

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COMPARISON OF YEAST AND PENICILLIN MAT AS SUPPLEMENTS TO DRY-MEAL DIETS FOR BROWN TROUT

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THE PURPOSE of this experiment was to compare the value of dried brewers' yeast and dried penicillin mat[1/] in trout diets. Five lots of brown trout (Salmo trutta) fingerlings were used, with 200 fish in each lot. During the course of the test it was necessary to remove fish from each lot to prevent overcrowding.

The fish were fed all they would eat twice a day, six days a week, no food being given on the seventh day. As the food was not weighed, no conversion figures were obtained. All fish were weighed and counted every second week. The experiment continued for 26 weeks.

In the present state of our knowledge of trout nutrition, it is difficult to devise an ideal diet for comparing two such products as yeast and penicillin mat. To add the products to an otherwise all-meat diet might necessitate an extensive series of diets so that mixtures containing different proportions of the ingredients could be tested. In such a series it would not be possible to achieve the same consistency in all the mixtures, and differences in consistency can greatly affect the utilization of the feed. Because of this fact, the addition of even nutritionally inert materials to a diet may improve its value. Thus Demoll (1927) obtained better conversion in rainbow trout through the addition of sawdust to a diet of ground fish.

In order to run a test with the fewest possible groups of fish, it was decided to make use of an all-meal formula. Up to the present time, no one has devised a diet consisting entirely of dry meals and capable of maintaining trout in good health and normal growth for any extended period of time. It has always been necessary to use a certain proportion of raw meat with the meals. It seems reasonable, however, to suppose that the break-down of trout on an all-meal diet might be postponed through the addition of such a rich source of the B-vitamins as brewers' yeast. It is well established that certain of the B-vitamins are essential for trout, although there is still much to be learned on this subject (Phillips and Brockway 1948; Phillips, Brockway and Rodgers, 1949; Wolf 1951). It is not known to what extent the vitamins in yeast are available to trout, though Phillips, Brockway, and Rodgers (1950) have shown that biotin from this source is well utilized. An all-meal diet, then, would appear to provide a better test for any benefits to be derived from a vitamin supplement than would a diet-mixture containing raw meat.

The proportions of the various ingredients of the test diets had to be altered several times after the experiment got

1/ Penicillin mat is the dried, ground mycelium of the Penicillium species used in the production of the antibiotic drug. It is coming into use in animal feeds. The mat used in this experiment was donated by the Bristol Laboratories, Syracuse, N. Y. The following analysis (percent basis) was furnished by the manufacturer: water 8.1, fat 5.3, fiber 6.1, protein 34.8, ash 14.3. A partial vitamin assay, also furnished, ran as follows (micrograms per gram): riboflavin 35-60, calcium pantothenate 75-150, vitamin B_1 10-20, vitamin B_{12} 0.03.

under way because of the difficulty in obtaining the same consistency. Dried brewers' yeast contains a small amount of gummy material which aids in binding the meals. As penicillin mat contains none of this gum, the mat diet did not hang together so well as that containing yeast. During the first part of the experiment superior growth was obtained from the yeast diet, yet it was felt that this superior growth might be entirely due to the fact that this mixture did not disintegrate so quickly in water rather than to any superiority in food-value of the yeast. It was not until a small quantity of gelatin had been incorporated in each diet that the difference in consistency was overcome and the diets were truly comparable.

The many small changes which were made before the gelatin was used will not be described. No change was made after the twelfth week, and for the last 14 weeks the diets were as follows:

cottonseed meal	- 12 gm.
soybean meal	- 12 gm.
dry skim milk	- 8 gm.
fish meal	- 10 gm.
oatmeal flour	- 12 gm.
gelatin	- 4 gm.
lard	- 4 gm.
cod-liver oil	- 2 gm.
salt	- 2 gm.
water	- 115 ml.
plus, for	
Lots 1 and 2:	
dried yeast	- 16 gm.
Lots 3 and 4:	
penicillin mat	- 16 gm.

Thus the total dry ingredients (including the cod-liver oil) came to 82 grams, to which 115 milliliters of water were added.

In the preparation of the diet, the oatmeal flour was thoroughly cooked in the water. The other ingredients were then added and stirred into the oatmeal. The warmth from the hot oatmeal was sufficient to dissolve the gelatin. After the mixture was cooled, it could be fed through a ricer, the "worms" hanging together sufficiently well to be ingested by the trout without any great loss through disintegration.

Besides the four lots on the meal diets, a fifth lot, serving as a check, was fed a diet of beef and pork spleen in about equal parts. This diet, in our experience, does not produce so good a growth as liver but is adequate for trout if most of the fat which adheres to these organs is trimmed off and excluded from the mixture.

Comparison of the growth of the two lots on the yeast diet with the growth of the two lots on the penicillin mat will be made in terms of increments in the cube root of the average weights of the fish in the lots. Haskell (1948) has shown that such increments remain uniform in normally growing fish regardless of the size and therefore produce a straight line when plotted on ordinary graph paper. Any other method of recording growth makes it difficult to compare the growth of different-sized fish, or of the same fish at different times.

In tables 1 and 2 the growth record for the five lots of trout is presented.

TABLE 1.--Weekly increase in cube root of weight,[1/] by 2-week periods, in the first 12 weeks, before use of gelatin

Lot No.	Diet	2-week period 1st	2d	3d	4th	5th	6th	Average
1	Yeast	34.0	58.5	81.0	57.5	78.0	76.0	63.2
2	Yeast	32.5	53.0	76.0	62.5	71.0	74.0	61.5
3	Mat	18.5	47.0	55.0	39.0	76.5	49.5	47.6
4	Mat	25.0	47.0	45.0	42.0	74.5	47.5	46.8
5	Meat	59.5	71.0	66.5	55.5	82.5	53.5	64.8

[1/] The increase in the cube root of the weight has been multiplied by 1,000 to eliminate decimals.

It will be noted that during the first 12 weeks (table 1), before the gelatin was included in the feed-mixtures, the growth, as indicated in the last column, was considerably better in the lots getting yeast than in those getting penicillin mat. The lot getting the meat diet did not grow appreciably better than the lots getting yeast.

During the last 14 weeks (table 2), after the gelatin had been included to obtain better binding, the lots getting penicillin mat grew just as well as those getting yeast. This improvement in growth is attributed entirely to the better physical state of the feed. If the improvement had been due to the amino acids supplied by the gelatin, it should have caused better growth also in the fish getting yeast--which it did not do. Field, Herman, and Elvehjem (1944) have suggested that the addition of gelatin to meal diets has a growth-promoting effect because of the high arginine and glycine content of the gelatin.

The falling-off of the growth rate in the meat-fed group during the last 6 weeks was remarkable. The meat used in this experiment was not prepared in the laboratory but was ground in the meat room of the main hatchery, where it was used, together with some liver, in the meat-and-meal mixture fed to all the fish in the ponds. The meat was not well trimmed of fat, and it is possible that when fed alone the amount of fat was excessive. Food consumption in this lot fell off as the experiment continued, but there were no signs of disease in the fish.

PATHOLOGY AND MORTALITY

Throughout the entire 26 weeks of the experiment, mortality was higher in all four of the meal-fed lots than in the meat-fed group, but no definite trend was evident--such as would have been present if the losses had been directly caused by dietary failure. For instance, during the last 4 weeks of observations there was no loss whatever except in Lot 3, in which three fish died.

By the end of the 26th week, when the experiment was terminated, it was obvious, however, that something was wrong in all the meal-fed lots. All contained a few abnormally light-colored fish and some fish which would slowly lose their balance and then straighten up again. Such fish would occasionally swim in a contorted, S-shaped position as if undergoing a muscular spasm. These symptoms were very similar to those reported by McCay and Tunison (1934) in brook trout after they were fed for 44 weeks on a diet consisting of equal parts of cottonseed meal, dry skim milk, and sheep plucks containing 1 percent formalin.

It seemed highly probable that Lots 1-4 would break down completely if continued much longer on the meal diets. It was therefore decided to discontinue the experiment so that these same fish could be used in a new series of tests to determine the cause of the condition.

TABLE 2.--Weekly increase in cube root of weight,[1/] by 2-week periods, in the last 14 weeks, with gelatin in diets

Lot No.	Diet	2-week period							Average
		7th	8th	9th	10th	11th	12th	13th	
1	Yeast	76.0	60.5	53.5	46.5	49.5	62.0	44.5	56.1
2	Yeast	75.0	59.0	50.0	53.5	49.5	47.5	57.5	56.0
3	Mat	114.0	58.5	69.0	60.0	51.0	54.5	44.0	64.4
4	Mat	81.5	46.5	66.0	54.5	59.0	44.5	54.0	58.0
5	Meat	65.0	63.0	40.0	64.0	35.0	32.0	33.0	47.4

[1/] The increase in the cube root of the weight has been multiplied by 1,000 to eliminate decimals.

Red-blood-cell counts were made on four unbalanced fish. These counts ran high, being as follows:

1,503,000
1,738,000
1,757,000
1,858,000

Norms for cell counts of trout have not yet been established, but on the basis of the writer's own experience with brown trout erythrocyte counts, these figures seem rather high and may indicate fluid loss on the part of the fish.

No pathological symptoms could be found in the gills or in any of the internal organs of the four fish for which cell counts were made. Pieces of various tissues were sectioned, stained, and subjected to microscopic examination. All appeared normal. The following tissues and organs were so examined: muscle from peduncle and from side, kidney, liver, spleen, intestine, and pancreas.

A study of the surviving fish is still in process, and a report will be published at some later date.

SUMMARY

Five lots of brown trout fingerlings were used in an experiment to test the relative values of dried brewers' yeast and penicillin mat as supplements to dry-meal diets. One lot was kept on a diet of beef and pork spleen as a check. Two lots were run in duplicate on the yeast and on the mat supplement. There were 200 fish in each lot at the start of the experiment. The test ran for 26 weeks.

After certain changes were made in the diets to assure the same consistency and therefore the same availability to the fish, the penicillin mat and the yeast gave about the same results as measured by the growth of the fish.

It would not have been possible to continue the experiment much beyond 26 weeks because of pathological symptoms which appeared in all four of the meal-fed groups. The cause of these symptoms was not determined but is still under investigation.

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COMPARISON OF FISH FOOD COSTS IN FEDERAL HATCHERIES IN 1945 AND 1949

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THE PROCUREMENT of suitable food for fish has been one of the major problems since the establishment of the first hatchery. Although labor is usually the highest single item in fish production, it can often be more readily obtained than fish food. The purchase of fish food has been made more difficult in the last 20 years by the competition of other markets--dog food, livestock feed, pharmaceuticals, and various products of human consumption. Fishery research during this same period has, in many instances, been pointed toward the development of cheaper diets that would nevertheless produce good growth and quality of fish. Most hatcheries now feed diets that are very different in composition from those employed 20 years ago. Meat remains the chief ingredient, particularly for the smaller trout and salmon, the remainder consisting of rough fish, fish wastes, and a variety of dry foods such as fish meal, milk, oil meals, and cereal by-products.

As far as is known, only one survey has ever been undertaken for the purpose of determining the kind and amount of fish food used in State, Federal, and commercial hatcheries in the United States. Fiedler and Sampson (1935) presented a picture of the fish-food business as reported by about 676 State, Federal, and commercial hatcheries. These hatcheries used 11,455,000 pounds of food valued at $608,000 during 1934. Of this, meat amounted to 8,554,000 pounds; fishery, 2,092,000 pounds; dairy, 184,000 pounds; and plant products, 625,000 pounds. As a result of a survey of fish culture, Tunison, Mullin, and Meehean (1949) reported that 38 States and the Federal hatcheries used approximately 29,750,000 pounds of fish food valued at $2,194,000 in 1948. Commercial hatcheries were not included in that survey, but on the basis of Fiedler and Sampson's survey, in which they reported private hatcheries as using 29 percent, it is believed that the total fish food used in the United States today amounts to nearly 42,000,000 pounds valued at approximately $3,000,000.

Fish food, like other commodities, has been subject to price inflation. To determine the degree of increase in food costs, as well as to review changes in diet composition, data submitted from the various Federal hatcheries for 1945 and 1949 have been summarized. The year 1945 was chosen because it was the end of the war period and before price controls were removed (June 1946). The data covering the purchase of various ingredients used in the Federal hatchery diets are shown in table 1, where they are also grouped under the Fish and Wildlife Service regions as indicated in figure 1.

Local prices and practices have usually dictated diet compositions in various parts of the country. Salmon flesh and viscera, byproducts of hatchery spawning and commercial cannery operations, have been relatively cheap on the West Coast. They can be fed in the raw state without causing a vitamin B_1 deficiency; they promote good growth and economical conversion. Diets used in a number of the hatcheries in the Southwestern and Rocky

TABLE 1.--Fish food purchased in 1945 and 1949

Kind of food	Regions 1		2		3		4		5		Total	
	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)
Beef liver (fresh)												
Quantity (lbs.)	--	--	21	--	--	--	--	--	4,222	--	4,243	--
Total cost	--	--	$6	--	--	--	--	--	$869	--	$875	--
Average cost	--	--	$0.29	--	--	--	--	--	$0.21	--	$0.21	--
Beef liver (condemned)												
Quantity (lbs.)	91,481	168,449	5,420	9,707	65,847	49,556	11,993	5,856	37,441	47,697	212,182	281,265
Total cost	$8,652	$19,519	$493	$1,311	$6,455	$6,152	$972	$889	$3,942	$6,468	$20,514	$34,339
Average cost	$0.09	$0.12	$0.09	$0.14	$0.10	$0.12	$0.08	$0.15	$0.11	$0.14	$0.10	$0.12
Sheep liver (fresh)												
Quantity (lbs.)	--	--	--	--	--	--	--	--	461	--	461	--
Total cost	--	--	--	--	--	--	--	--	$100	--	$100	--
Average cost	--	--	--	--	--	--	--	--	$0.22	--	$0.22	--
Sheep liver (condemned)												
Quantity (lbs.)	--	--	--	--	820	--	--	--	920	--	1,740	--
Total cost	--	--	--	--	$66	--	--	--	$80	--	$146	--
Average cost	--	--	--	--	$0.08	--	--	--	$0.09	--	$0.08	--
Pork liver (fresh)												
Quantity (lbs.)	--	--	--	--	--	--	--	--	14	--	14	--
Total cost	--	--	--	--	--	--	--	--	$2	--	$2	--
Average cost	--	--	--	--	--	--	--	--	$0.14	--	$0.14	--
Pork liver (condemned)												
Quantity (lbs.)	22,103	104,527	158	2,491	15,300	18,447	400	15,534	2,742	--	40,703	140,999
Total cost	$1,611	$9,603	$15	$220	$1,224	$1,483	$34	$1,601	$258	--	$3,142	$12,907
Average cost	$0.07	$0.09	$0.09	$0.09	$0.08	$0.08	$0.09	$0.10	$0.09	--	$0.08	$0.09
Horse liver (fresh)												
Quantity (lbs.)	2,125	5,306	--	1,919	394	15,773	--	--	1,092	--	3,611	22,998
Total cost	$234	$669	--	$98	$45	$1,692	--	--	$117	--	$398	$2,459
Average cost	$0.11	$0.13	--	$0.05	$0.11	$0.11	--	--	$0.11	--	$0.11	$0.11
Livers, mixed (condemned)												
Quantity (lbs.)	--	--	--	--	--	--	--	6,454	--	11,700	--	18,154
Total cost	--	--	--	--	--	--	--	$916	--	$1,638	--	$2,554
Average cost	--	--	--	--	--	--	--	$0.14	--	$0.14	--	$0.14
Beef spleen												
Quantity (lbs.)	37,383	5,976	2,559	10,626	19,920	31,896	8,082	33,389	92,574	50,261	160,518	132,148
Total cost	$2,000	$464	$131	$1,272	$842	$2,895	$442	$3,634	$4,833	$5,885	$8,248	$14,150
Average cost	$0.05	$0.08	$0.05	$0.12	$0.04	$0.09	$0.05	$0.11	$0.05	$0.12	$0.05	$0.11
Pork spleen												
Quantity (lbs.)	12,065	47,957	11,295	8,401	4,766	3,664	1,925	6,110	112,712	51,086	142,763	117,218
Total cost	$867	$6,371	$561	$976	$216	$393	$141	$720	$7,602	$6,454	$9,387	$14,916
Average cost	$0.07	$0.13	$0.05	$0.12	$0.05	$0.11	$0.07	$0.12	$0.07	$0.13	$0.07	$0.13

TABLE 1.--Fish food purchased in 1945 and 1949--continued

Kind of food	Regions 1 (1945)	1 (1949)	2 (1945)	2 (1949)	3 (1945)	3 (1949)	4 (1945)	4 (1949)	5 (1945)	5 (1949)	Total (1945)	Total (1949)
Spleen, mixed												
Quantity (lbs.)	--	62,023	--	--	--	--	3,781	--	--	32,887	3,781	94,910
Total cost	--	$5,427	--	--	--	--	$282	--	--	$3,527	$282	$8,954
Average cost	--	$0.09	--	--	--	--	$0.07	--	--	$0.11	$0.07	$0.09
Beef heart												
Quantity (lbs.)	--	--	507	--	--	--	--	--	2,999	--	3,506	--
Total cost	--	--	$82	--	--	--	--	--	$431	--	$513	--
Average cost	--	--	$0.16	--	--	--	--	--	$0.14	--	$0.15	--
Beef lungs												
Quantity (lbs.)	12,599	21,899	5,352	--	--	--	2,468	433	979	--	21,398	22,332
Total cost	$313	$413	$218	--	--	--	$148	$52	$52	--	$731	$465
Average cost	$0.02	$0.02	$0.04	--	--	--	$0.06	$0.12	$0.05	--	$0.03	$0.02
Beef plucks												
Quantity (lbs.)	17,442	--	--	--	--	--	--	--	--	--	17,442	--
Total cost	$624	--	--	--	--	--	--	--	--	--	$624	--
Average cost	$0.04	--	--	--	--	--	--	--	--	--	$0.04	--
Horse plucks												
Quantity (lbs.)	--	--	--	--	18,905	--	--	--	--	--	18,905	--
Total cost	--	--	--	--	$159	--	--	--	--	--	$159	--
Average cost	--	--	--	--	$0.01	--	--	--	--	--	$0.01	--
Tripe												
Quantity (lbs.)	30,916	28,600	--	--	--	--	--	--	--	--	30,916	28,600
Total cost	$583	$429	--	--	--	--	--	--	--	--	$583	$429
Average cost	$0.02	$0.02	--	--	--	--	--	--	--	--	$0.02	$0.02
Horse meat												
Quantity (lbs.)	105,219	144,433	39,906	36,048	21,996	38,818	--	--	366	--	167,487	219,299
Total cost	$5,524	$9,371	$1,575	$1,877	$1,057	$2,397	--	--	$28	--	$8,184	$13,645
Average cost	$0.05	$0.06	$0.04	$0.05	$0.05	$0.06	--	--	$0.08	--	$0.05	$0.06
Meats, miscellaneous and unclassified												
Quantity (lbs.)	30,695	86,476	888	[1] 1,002	--	[2] 231	40,039	[3] 20,220	94,031	[2] 409	165,653	108,338
Total cost	$1,418	$6,669	$44	$226	--	$53	$3,315	$2,277	$5,679	$78	$10,456	$9,303
Average cost	$0.05	$0.08	$0.05	$0.23	--	$0.23	$0.08	$0.11	$0.06	$0.19	$0.06	$0.09

[1] Sheep liver (fresh), 893 lbs. at 24¢, or $211; sheep liver (condemned), 109 lbs. at 14¢, or $15. (893 x $0.2362 = $211. All computations to the nearest dollar.)
[2] Beef heart (fresh).
[3] Cortland #6 - percentage meats and dry feeds not shown.

TABLE 1.--Fish food purchased in 1945 and 1949--continued

Kind of food	Regions 1		2		3		4		5		Total	
	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)
Total meats												
Quantity (lbs.)	362,028	675,646	66,106	70,194	147,948	158,385	68,688	87,996	350,553	194,040	995,323	1,186,261
Total cost	$21,826	$58,935	$3,125	$5,980	$10,064	$15,067	$5,334	$10,089	$23,993	$24,050	$64,342	$114,121
Average cost	$0.06	$0.09	$0.05	$0.09	$0.07	$0.10	$0.08	$0.11	$0.07	$0.12	$0.06	$0.10
Salmon flesh												
Quantity (lbs.)	68,079	33,391	--	--	--	--	--	--	--	--	68,079	33,391
Total cost	$1,976	$500	--	--	--	--	--	--	--	--	$1,976	$500
Average cost	$0.03	$0.01	--	--	--	--	--	--	--	--	$0.03	$0.01
Salmon viscera												
Quantity (lbs.)	31,778	120,041	--	--	--	--	--	--	--	--	31,778	120,041
Total cost	$706	$9,224	--	--	--	--	--	--	--	--	$706	$9,224
Average cost	$0.02	$0.08	--	--	--	--	--	--	--	--	$0.02	$0.08
Fish, miscellaneous and unclassified												
Quantity (lbs.)	18,616	4/ 20,416	5,900	148	4/ 106	--	--	--	1,692	--	26,314	20,564
Total cost	$553	$1,512	$708	$13	$5	--	--	--	$150	--	$1,416	$1,525
Average cost	$0.03	$0.07	$0.12	$0.09	$0.05	--	--	--	$0.09	--	$0.05	$0.07
Total fish												
Quantity (lbs.)	118,473	173,848	5,900	148	106	--	--	--	1,692	--	126,171	173,996
Total cost	$3,235	$11,236	$708	$13	$5	--	--	--	$150	--	$4,098	$11,249
Average cost	$0.03	$0.06	$0.12	$0.09	$0.05	--	--	--	$0.09	--	$0.03	$0.06
Dried skim milk												
Quantity (lbs.)	--	--	2,254	432	1,667	416	--	1,547	38,628	21,365	42,549	23,760
Total cost	--	--	$294	$78	$188	$47	--	$220	$3,307	$2,642	$3,789	$2,987
Average cost	--	--	$0.13	$0.18	$0.11	$0.11	--	$0.14	$0.09	$0.12	$0.09	$0.13
Dried whey												
Quantity (lbs.)	--	--	--	--	--	--	--	--	43	--	43	--
Total cost	--	--	--	--	--	--	--	--	$3	--	$3	--
Average cost	--	--	--	--	--	--	--	--	$0.07	--	$0.07	--
Fish meal												
Quantity (lbs.)	408	43,255	2,248	11,384	4,146	600	2,497	5,710	69,794	51,273	79,093	112,222
Total cost	$39	$3,744	$154	$1,300	$192	$52	$120	$471	$2,901	$4,279	$3,406	$9,846
Average cost	$0.10	$0.09	$0.07	$0.11	$0.05	$0.09	$0.05	$0.08	$0.04	$0.08	$0.04	$0.09
Cottonseed meal												
Quantity (lbs.)	--	1,016	2,538	3,860	--	1,400	7,770	9,371	69,125	42,190	79,433	57,837
Total cost	--	$55	$98	$183	--	$61	$240	$348	$2,322	$1,990	$2,660	$2,637
Average cost	--	$0.05	$0.04	$0.05	--	$0.04	$0.03	$0.04	$0.03	$0.05	$0.03	$0.05

4/ Carp.

TABLE 1.--Fish food purchased in 1945 and 1949--continued

Kind of food	Regions 1		2		3		4		5		Total	
	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)
Wheat middlings												
Quantity (lbs.)	---	916	4,133	3,862	2,600	1,800	6,664	9,942	59,358	44,182	72,755	60,702
Total cost	---	$31	$139	$124	$67	$57	$209	$374	$1,878	$1,596	$2,293	$2,182
Average cost	---	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	$0.04	$0.03	$0.04	$0.03	$0.04
Red dog flour												
Quantity (lbs.)	---	---	---	---	12,600	---	---	---	6,897	---	19,497	---
Total cost	---	---	---	---	$308	---	---	---	$175	---	$483	---
Average cost	---	---	---	---	$0.02	---	---	---	$0.03	---	$0.02	---
Soybean meal												
Quantity (lbs.)	---	---	---	---	---	---	3,000	---	1,838	---	4,838	---
Total cost	---	---	---	---	---	---	$97	---	$57	---	$154	---
Average cost	---	---	---	---	---	---	$0.03	---	$0.03	---	$0.03	---
Flour												
Quantity (lbs.)	---	---	---	---	400	---	8,100	---	300	---	8,800	---
Total cost	---	---	---	---	$10	---	$35	---	$11	---	$56	---
Average cost	---	---	---	---	$0.03	---	$0.00	---	$0.04	---	$0.01	---
Salt												
Quantity (lbs.)	2,117	8,247	727	2,867	1,337	1,032	---	---	8,453	5,983	12,634	18,129
Total cost	$21	$106	$12	$57	$23	$17	---	---	$96	$80	$152	$260
Average cost	$0.01	$0.01	$0.02	$0.02	$0.02	$0.02	---	---	$0.01	$0.01	$0.01	$0.01
Cortland #6 Mixture												
Quantity (lbs.)	---	---	216	14,144	1,894	57,588	---	29,139	10,689	---	12,799	100,871
Total cost	---	---	$14	$1,226	$114	$4,729	---	$2,436	$517	---	$645	$8,391
Average cost	---	---	$0.06	$0.09	$0.06	$0.08	---	$0.08	$0.05	---	$0.05	$0.08
Dry feeds, miscellaneous and unclassified												
Quantity (lbs.)	[5]/ 3,905	20,195	11,966	---	49,649	1,718	[6]/ 1,179	[7]/ 21,124	[8]/ 2,448	[9]/ 3,418	69,147	46,455
Total cost	$94	$1,856	$343	---	$1,308	$66	$61	$2,330	$67	$548	$1,873	$4,800
Average cost	$0.02	$0.09	$0.03	---	$0.03	$0.04	$0.05	$0.11	$0.03	$0.16	$0.03	$0.10
Total dry feeds												
Quantity (lbs.)	6,430	73,629	24,082	36,549	74,293	64,554	29,210	76,833	267,573	168,411	401,588	419,976
Total cost	$154	$5,792	$1,054	$2,968	$2,210	$5,029	$762	$6,179	$11,334	$11,135	$15,514	$31,103
Average cost	$0.02	$0.08	$0.04	$0.08	$0.03	$0.08	$0.03	$0.08	$0.04	$0.07	$0.04	$0.07

5/ Includes bone and meat meal, 972 lbs. at 4¢, or $38.
6/ Meat meal.
7/ Meat scrap, 1,260 lbs. at 8¢, or $95; Cortland #6, 19,864 lbs. at 11¢, or $2,235. Percentage meat and dry feeds not shown.
8/ Includes bone and meat meal, 37 lbs. at 4¢, or $1, and buttermilk, 37 lbs. at 5¢, or $2.
9/ Distillers' dried solubles, 816 lbs. at 4¢, or $35; paprika, 559 lbs. at 40¢, or $222; dried buttermilk, 2,043 lbs. at 14¢, or $291.

TABLE 1.--Fish food purchased in 1945 and 1949--continued

Kind of food	Regions 1		2		3		4		5		Total	
	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)	(1945)	(1949)
Commercial feeds												
Quantity (lbs.)	8,426	23,032	1,069	--	5,125	180	100	2,536	50,937	--	65,657	25,748
Total cost	$355	$2,417	$99	--	$340	$46	$4	$107	$4,455	--	$5,253	$2,570
Average cost	$0.04	$0.10	$0.09	--	$0.07	$0.26	$0.04	$0.04	$0.09	--	$0.08	$0.10
Meat												
Quantity (lbs.)	362,028	675,646	66,106	70,194	147,948	158,385	68,688	87,996	350,553	194,040	995,323	1,186,261
Total cost	$21,826	$58,935	$3,125	$5,980	$10,064	$15,067	$5,334	$10,089	$23,993	$24,050	$64,342	$114,121
Average cost	$0.06	$0.09	$0.05	$0.09	$0.07	$0.10	$0.08	$0.11	$0.07	$0.12	$0.06	$0.10
Percent of total (lbs.)	73	71	68	66	65	71	70	53	52	54	63	66
Dry feeds												
Quantity (lbs.)	6,430	73,629	24,082	36,549	74,293	64,554	29,210	76,833	267,573	168,411	401,588	419,976
Total cost	$154	$5,792	$1,054	$2,968	$2,210	$5,029	$762	$6,179	$11,334	$11,135	$15,514	$31,103
Average cost	$0.02	$0.08	$0.04	$0.08	$0.03	$0.08	$0.03	$0.08	$0.04	$0.07	$0.04	$0.07
Percent of total (lbs.)	1	8	25	34	33	29	30	46	40	46	25	23
Fish												
Quantity (lbs.)	118,473	173,848	5,900	148	106	--	--	--	1,692	--	126,171	173,996
Total cost	$3,235	$11,236	$708	$13	$5	--	--	--	$150	--	$4,098	$11,249
Average cost	$0.03	$0.06	$0.12	$0.09	$0.05	--	--	--	$0.09	--	$0.03	$0.06
Percent of total (lbs.)	24	18	6	--	--	--	--	--	--	--	8	10
Commercial feeds												
Quantity (lbs.)	8,426	23,032	1,069	--	5,125	180	100	2,536	50,937	--	65,657	25,748
Total cost	$355	$2,417	$99	--	$340	$46	$4	$107	$4,455	--	$5,253	$2,570
Average cost	$0.04	$0.10	$0.09	--	$0.07	$0.26	$0.04	$0.04	$0.09	--	$0.08	$0.10
Percent of total (lbs.)	2	3	1	--	2	--	--	1	8	--	4	1
Total feeds purchased												
Quantity (lbs.)	495,357	946,155	97,157	106,891	227,472	223,119	97,998	167,365	670,755	362,451	1,588,739	1,805,981
Total cost	$25,570	$78,380	$4,986	$8,961	$12,619	$20,142	$6,100	$16,375	$39,932	$35,185	$89,207	$159,043
Average cost	$0.05	$0.08	$0.05	$0.08	$0.06	$0.09	$0.06	$0.10	$0.06	$0.10	$0.06	$0.09

FIGURE 1.--U. S. Fish-Cultural Stations, by Regions, operating in 1949.

Mountain States contain appreciable quantities of horse meat. Wild horses have been available for fish food and, at the same time, their slaughter improved range conditions for cattle. Hatcheries in the eastern part of the country have used increasing amounts of dry foods as supplements to the meat diet. These variations among the Service regions, as well as the changes that have accrued during this 5-year period, are shown in the summaries of table 1.

It is interesting to note that, taken on a nation-wide basis, the ratios of the various ingredients purchased have remained about the same: 1945--meat 63, dry feeds 25, fish 8, and commercial 4; 1949--meat 66, dry feeds 23, fish 10, and commercial 1.

The Federal hatcheries purchased about 14 percent more food in 1949 than in 1945--1,806,000 pounds and 1,589,000 pounds, respectively. The increase in unit price of this food amounted to 57 percent--from $0.056 to $0.088. Table 2 lists the changes in unit prices of fish foods purchased in 1945 and 1949. Salmon viscera show the greatest increase--246 percent. The spleens have almost doubled in price, as is also true for fish meal. Other increases have been more moderate although significant in necessitating increased expenditures for fish food. Decreases are shown for four items, none of which is a primary ingredient of the diets used in the various Service regions.

During the last decade nutritional research on trout and salmon has made great progress in determining the vitamin requirements and means of preventing anemia. In general, scientists and fish-culturists are not satisfied with the adequacy and efficiency of present salmon and trout diets. The diets surely can be improved. Many of the fish losses at hatcheries are, without doubt, the result of malnutrition and vitamin deficiencies.

A lack of vitamin B_1 is known to cause mortality in trout. The "blue slime" disease is quite likely the result of a biotin deficiency. Anemia in trout can be caused by feeding diets that lack certain members of the vitamin B complex. Nutritional gill disease results from

TABLE 2.--Comparison of fish-food costs in 1945 and 1949

Kind of food	Price per hundredweight 1945	1949	Increase or decrease (Percent)
Beef liver (condemned)	$9.67	$12.21	26
Pork liver (condemned)	7.72	9.15	19
Horse liver (fresh)	10.97	10.69	(-) 3
Beef spleen	5.14	10.71	108
Pork spleen	6.58	12.73	93
Beef lungs	3.42	2.08	(-) 39
Tripe	1.89	1.50	(-) 21
Horse meat	4.89	6.22	27
Salmon flesh	2.90	1.50	(-) 48
Salmon viscera	2.22	7.68	246
Dried skim milk	8.91	12.57	41
Fish meal	4.31	8.77	103
Cottonseed meal	3.35	4.56	36
Wheat middlings	3.15	3.59	14
Salt	1.20	1.43	19

feeding trout diets that contain insufficient amounts of pantothenic acid. No doubt fish die from deficiencies of other vitamins or food essentials without exhibiting external symptoms that can be recognized with present-day knowledge. It must also be realized that a major problem confronting the fish-culturist is the presentation of the diet in such a manner that complete ingestion will result. Salt, when added to spleen and certain other meats, will form a rubber-like mass that improves the binding qualities of the diet. However, as larger portions of dry feed are employed, the binding becomes more difficult. Dry diets have been pelleted, and this form offers a possible solution although these diets must be supplemented with meats several times a week.

Until we know more of the nutritional requirements of fish and until the mechanics of diet preparation are improved, it will be necessary for fish-culturists to use diets composed of at least 50 percent meat, the balance being formed by economical supplements such as fish wastes or dry foods.

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The removal of only the game fishes from waters closed to commercial fishing may result in the decline of the desired species because the coarse fishes, competing with the game fish for the food in these waters, are permitted to breed and grow undisturbed.

AN INCIDENT OF HIGH MORTALITY AMONG LARGE RAINBOW TROUT AFTER TREATMENT WITH PYRIDYLMERCURIC ACETATE

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THE GENERAL Electric Company maintains an aquatic biology laboratory at the Hanford Works (Richland, Washington), which is associated with the operation of the atomic piles. This laboratory uses water pumped directly from the Columbia River for experiments with trout and salmon. Disease problems, particularly with Chondrococcus columnaris, have been of major concern each summer, when warm water temperatures (68° F.) prevail. During the summers of 1946, 1947, 1948, and 1949, routine prophylactic treatments with roccal were administered with only limited success. Because considerable promise was indicated for pyridylmercuric acetate (PMA) as a safe and effective agent for the control and treatment of external infections of salmonoid fish, this new chemical was tried during the summer of 1950.

A treatment of PMA at the rate of 1:500,000 for 1 hour, as recommended by Burrows (1949), was first administered in May, in solution form, to a single small concrete pond of yearling rainbow trout averaging 8 inches in length. The fish showed no signs of distress at the end of the treatment, and the pond (which we will designate as Pond A) was flushed out and returned to normal. During the next 12 hours, however, 13 percent of the fish died. Because of this mortality, no other ponds were treated at that time. As the mortality might have been due to some factor other than the PMA, Pond A was treated again about 2 weeks later. The result was a loss of about 10 percent of the fish. On each of these occasions the fish had been fed soon after the treatment, and thus our results appeared similar to those that were observed by Seaman.[1/] Early in August a third PMA treatment was given as a prophylactic to the trout in Pond A, but this time they were not fed until about 24 hours after treatment. No mortality resulted.

About the middle of August, a rather serious outbreak of columnaris and, simultaneously, an infestation of Ichthyophthirius appeared in two other small ponds (which we will call Ponds B and C). The temperature of the water in Ponds B and C was 67° F., as compared with 66° F. in Pond A. To eliminate the Ichthyophthirius, the depth of water in the ponds was reduced to about 6 inches, a strong flow of water was turned on, and three salt treatments (3 percent for 20 minutes) and one roccal treatment (1:50,000 for 1 hour) were given during a 7-day period. Although the fish showed definite improvement, we were curious as to what effect PMA would have on the bacterial infection. Because of the apparent absence of a toxic effect in Pond A when the fish were not fed immediately after treatment, PMA was given to Ponds A, B, C, and two others, Ponds D and E. No loss of fish resulted in Ponds A, C, D, or E, and a 5-percent loss that occurred in Pond B was attributed to the disease organisms rather than to the chemical. By the following week the fish were again

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1/See "Warning to users of pyridylmercuric acetate," Prog. Fish-Cult. 12 (3): 126.

actively feeding, mortality was nil, and the fish appeared normal.

Eleven days after the previous treatment, PMA was again administered to the fish in the five ponds as a prophylactic. Rather surprising and disastrous consequences resulted. During the next 12 hours, the following mortalities occurred:

Pond A - None
Pond B - 11 percent
Pond C - None
Pond D - 18 percent
Pond E - 61 percent

We have been unable to explain the cause of the catastrophic mortality in Pond E or its irregular pattern. All the fish were fed about 6 hours prior to treatment, and none were fed subsequently. All ponds were identical in size and contained similar numbers of fish; the fish in Pond A were slightly larger than the others, while those in Ponds B and C were slightly smaller. All ponds were carefully cleaned prior to treatment and were flushed out with fresh water at the end of the 60-minute exposure. Treatment conditions were uniform. All the fish were active, and they showed no distress during or immediately after treatment. The temperature of the water in Ponds D and E was identical with that of Pond A. Each pond was entirely independent of every other pond.

The fish which were affected were first observed to be dying some 3 hours after treatment. No distress or struggling actions were observed, but the stricken individuals became lethargic and then moribund on the bottoms of the ponds and soon expired after a few feeble respiratory movements. On some of the live fish light colored areas appeared on the sides and backs, producing a mottled appearance. Several specimens exhibited small scattered hemorrhages at the base of the paired fins. Autopsy revealed an inconsistent syndrome. Nearly all of the specimens displayed hyperemia of the lower gut. Small areas of hemorrhage were usually present in the liver but may have been due to post-mortem changes. The gastric epithelium in about half of the fish showed only slight involvement. The stomachs contained food from the feeding prior to treatment, but none were bloated as mentioned by Seaman.[2/] The testes of the males were usually well developed and in several specimens showed a pronounced hyperemia. The kidneys, peritoneum, spleen, and pericardium showed no visible lesions.

PMA treatments similar to those given the large trout in the ponds were administered to juvenile rainbow trout (2 inches in length) in standard hatchery troughs, and only slight mortality (1 percent or less) resulted. There would seem to be a possibility that large rainbow trout are more susceptible to PMA than small juvenile fish.

Since preparing the manuscript for this paper, the senior author has discussed the problem with Dr. Robert Rucker of the U. S. Fish and Wildlife Service. Dr. Rucker has corresponded with others who have experienced difficulty in treating rainbow trout with PMA and pointed out the apparent sensitivity of this particular species of trout to the chemical. He also mentioned that Dr. S. F. Snieszko of the Leetown Experimental Station had prepared a paper on his results which will appear in this periodical. /See Editors' note./

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2/See footnote, preceding page.

The paper mentioned by Dr. Rucker to Dr. Foster has appeared as: "The toxicity of pyridylmercuric acetate technical (PMA) to rainbow trout (Salmo gairdneri)" by E. O. Rodgers, B. H. Hazen, S. B. Friddle, and S. F. Snieszko. Prog. Fish-Cult. 13 (2): 71-73.
--The EDITORS.

A METHOD OF MEASURING THE NATURAL FOOD CONTENT OF REARING PONDS

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ONE OF THE most important problems in raising fish in rearing ponds is to provide enough food for maximum growth. Without accurate information on the amount of food produced by each pond and the amount required by a certain number of fish, pond stocking and pond fertilization must be done by guesswork. As economical pond operation depends on a knowledge of the seasonal abundance cycles of the important food organisms, there is need for a method of sampling the food supply of various ponds at periodic intervals through the growing season. The method must be simple enough for practical hatchery use and accurate enough for detailed pond studies.

As cladocerans and copepods are the main foods of young fish, the method described here is based on a tow net that will collect these forms in large quantities. The mesh of the cloth is large enough to allow the small net-plugging organisms to pass through. Consequently, the net can be towed a hundred feet or more without plugging. The amount of fish food collected can be measured in the field or, if necessary, can be taken to the laboratory for detailed analysis.

The conical net is 10 inches in diameter, 28 inches long, and is made of 6XX bolting cloth with a collar of unbleached muslin. A stiff wire in the collar holds the net open. The weight of the wire causes the net to remain just below the surface of the water. A wide-mouthed bottle at the small end of the net is a suitable receptacle for the organisms screened out by the net.

The net can be towed in several ways, but the usual method is to wade in 2 to 4 feet of water at a slow and steady rate of speed. The net should be held to one side with a short pole in order to avoid the silt kicked up by the wader. The operator should pace the distance the net is towed so that he is free to pick his way along the shore and avoid areas of debris and filamentous algae. Each man that uses the net must check his wading pace against a known distance along the shore.

The distance the net is towed will depend on the size of the pond, but in most ponds a run of 1,000 feet is necessary for a suitable sample. At the end of each 100 feet, the net should be examined to see if it is full of organisms. If the bottle is full, it should be emptied; if not, the run can be continued until the bottle is full or until the end of the 1,000 feet is reached. At ordinary wading speed, a new net will screen about 1,500 gallons of water when towed 1,000 feet. Within 3 years the efficiency will drop so that the same net will screen only 900 gallons in the same distance (Welch 1948: 278-279).

At the end of each run, the contents of the net are emptied into a graduated cylinder and preserved with formalin. If the sample contains large amounts of minute algae, chloroform should be used instead to kill the organisms. When killed by chloroform, even the small algae become heavy enough to settle in a short time. The preserved sample should be allowed to stand until the cladocerans and the copepods have settled to the bottom and their total volume can be determined. The algae will settle later and can be measured at that time. The layers

(Left) Tow net of 6XX bolting cloth.
(Below) Towing net in a minnow pond.

(Photos courtesy Minnesota Conservation Department)

of plant and animal plankton can be differentiated by both color and texture.

After the volumes have been recorded, the sample can be either discarded or bottled and labeled for detailed laboratory analysis. Samples killed in chloroform should have formalin added to them before they are bottled.

By collecting plankton volumes on a group of hatchery ponds at 2-week intervals for a number of years, the hatchery operator will obtain a basis for evaluating his techniques and simplifying his operations. At present, it is difficult to determine whether a pond failure is due to a lack of food, poor weather, or other unfavorable factors. A record of the food crop through the season eliminates one factor from the guesswork.

For detailed studies, these volumes will not be accurate because they include the volume of the food organisms, the volume of nonfood organisms, and the volume of silt in the water. By careful operation, the collector can usually keep the silt volume so low that it will not affect the total volumes to a noticeable degree, but in some ponds it is impossible to avoid a considerable quantity of silt and debris. In most ponds, the research worker will get the best results by taking the sample to the laboratory for detailed analysis.

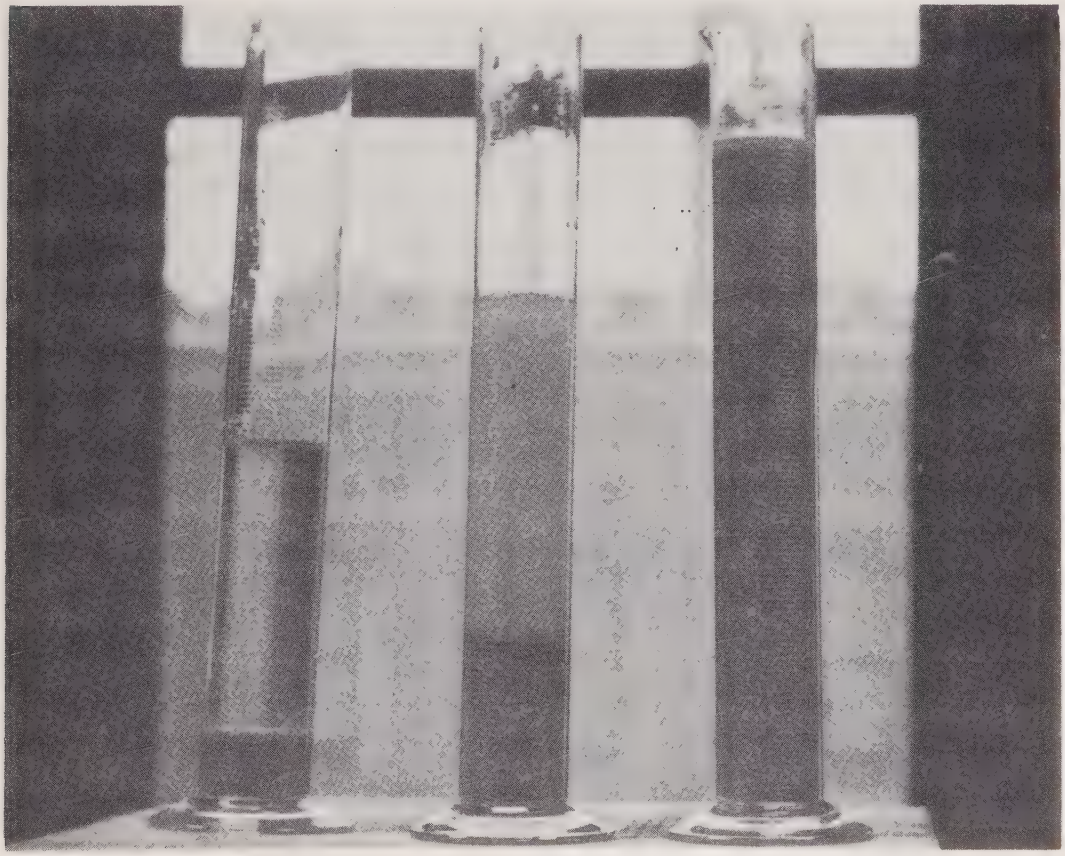
Before the volumes of the different food organisms can be determined accurately, it is necessary to prepare a table showing the number of cladocerans and copepods per milliliter for each length class. For an evaluation of the algal production, another table must be constructed to show the number of each species of algae per milliliter. Table 1 shows some of the zooplankton figures used in the Minnesota pond studies. In

TABLE 1.--Number of certain organisms per milliliter for various length classes

Length of organisms (Millimeters)	Number of daphnia per milliliter[1/]	Number of Diaptomus per milliliter[1/]
0.30	17,250	25,000
.40	10,600	13,500
.50	7,100	8,000
.60	5,300	5,350
.70	4,000	3,800
.80	3,200	2,800
.90	2,600	2,150
1.00	2,200	1,700
1.10	1,850	1,350
1.20	1,600	1,150
1.30	1,375	950
1.40	1,225	780
1.50	1,100	690

[1/] Settled wet volumes.

Two net samples from three ponds. The three graduates show the range of zooplankton volumes collected in three ponds at the same season of the year. The dark layer in each graduate is made up of zooplankton. The upper layer in the center graduate is made up of algae in suspension. The white streaks are Chaoboris larvae.



order to complete the calculations, it is necessary to know also the amount of water the net screens in a 1,000-foot tow and the weight of 1 milliliter of zooplankton and 1 milliliter of phytoplankton.

With this information available, the calculations can be made in the following steps:

1. Determine the number of each species of zooplankton in the sample by the standard methods, using a Sedgewick-Rafter counting cell.

2. Measure the length of at least 25 individuals of each species with an ocular micrometer and average the results.

3. Look up the number of organisms per milliliter for each length class in table 1.

4. Divide the number of organisms in the sample (step 1) by the number per milliliter (step 3) to obtain the volume of that species.

5. Convert the volume of plankton per 1,000-foot tow to pounds of organisms per acre foot.

EXAMPLE:

Length of the tow - 1,000 feet.
Total volume of the sample - 500 milliliters.
Volume of the organisms (field determination) - 36 milliliters.

Species	Number of organisms per sample ---Step 1---	Average length of organisms ---Step 2--- (Millimeters)	Number of organisms per milliliter ----Step 3-----	Volume of organisms in sample ---Step 4---- (Milliliters)
Daphnia	500	0.60	5,300	0.094
Holopedium	500	1.50	1,100	.454
Cyclops	1,000	.55	6,500	.154
Diaptomus	12,000	2.06	360	33.333
Total				34.035

The difference between the field volume and the laboratory calculated volume is the amount of silt and organic matter in the sample.

To complete the calculation, step 5 is undertaken as follows: When the amount of water screened by the net used in 1950 and the weight of a milliliter of zooplankton are considered together, a factor of 0.481 is obtained. This factor converts the volume per 1,000-foot tow to pounds of zooplankton per acre foot. The 1950 factor for algae is 0.458. Therefore, the calculated volume of 34.035 is multiplied by 0.481 to get 16.37 pounds of zooplankton per acre foot of water. The volume of algae in this sample was too small to determine accurately.

The zooplankton in one pond may range from 5 to 400 pounds per acre foot during the season, and the average seasonal poundages for the ponds being compared may range from 25 to 250 pounds per acre foot. The volumes obtained by the tow net and this series of calculations are not accurate to the exact milliliter, and the poundages are not accurate to the exact pound, but they are close enough for the purpose of computing forage ratios, food volumes, and the ability of the pond to rear fish.

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SULFADIAZINE FOR KIDNEY DISEASE

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THE BLUEBACK salmon fingerlings (Oncorhynchus nerka) at the U. S. Fish-Cultural Station at Winthrop, Washington, underwent an infection that was caused by a very short, Gram-positive, nonmotile, rod-shaped bacterium. A further description is impossible at this time, as the organism has not been grown satisfactorily for proper identification. The disease was characterized by white, raised areas of dead tissue mainly in the kidney: for this reason it is referred to as kidney disease. Belding and Merrill (1935) described a disease among the brook, brown, and rainbow trout at a State hatchery in Massachusetts which, from the description, might be the same as kidney disease. J. H. Wales of the California Division of Fish and Game described (unpublished manuscript, 1941) a disease in hatchery trout in California which seems to be identical to kidney disease. He states:

> "... However, it does not attack the rainbow or brown in this State to a serious extent and for that reason we may expect relatively little trouble from it. The writer has found it in yearling rainbow and in fingerling brook and brown but by far the most susceptible fish have been the yearling and two year old brook. This fact is very important to the commercial trout breeders who would otherwise find the brook the most economical trout for the markets. The writer saw one large commercial establishment lose nearly all of its many thousands of marketable trout from White Boil."

This disease or kidney disease has been identified in young salmon from Oregon State hatcheries by T. B. McKee (personal communication, 1950) and from Washington State hatcheries by Ordal and Earp (1950). The species of fish affected have been the blueback salmon, the king salmon (O. tschawytscha), and the silver salmon (O. kisutch).

Kidney disease at the Winthrop Station first appeared in the summer of 1948, infecting mainly the blueback salmon fingerlings. Silver salmon fingerlings were also affected to a lesser degree, but they seemed more resistant and responded to sulfadiazine therapy more effectively than the bluebacks. During the 1949-50 season the blueback fingerlings again contracted the disease, whereas chinook salmon fingerlings held under similar conditions remained healthy and were not infected. The blueback salmon were given sulfadiazine therapy in an attempt to eliminate the kidney infection before the bulk of the stock was planted on October 1. At this time no fish having gross kidney lesions were found. Later, during October, fungus made its appearance and a fluorescent pseudomonad pathogenic to salmon was isolated from the group of bluebacks that was being held for winter rearing. The fungus infection was controlled by weekly treatments of 1:100,000 pyridylmercuric acetate for 1 hour.[1/] The kidney infection was apparently eliminated by the sulfadiazine therapy, as evidenced by the disappearance of the gross kidney lesions, but the fish continued to die.

[1/] The next season 1:200,000 pyridylmercuric acetate proved effective in controlling the fungus infection among the blueback salmon fingerlings. When the pyridylmercuric acetate was discontinued in one pond, fungus appeared on the fish, but immediate treatment eliminated the infection.

Subsequently the fluorescent pseudomonad and later Pseudomonas hydrophila were isolated from this group of fish. These bacteria were shown to be pathogenic and may have been responsible for the continued mortality.

On the basis of the encouraging use of sulfadiazine for kidney disease, the following experiment was conducted at the Winthrop Station to confirm the chemotherapeutic value of the drug. The fish (192 in number) used in this experiment were a group of 6-inch blueback salmon which remained from a stock of about 3,000 fish held for experimental studies on kidney disease. This stock of fish had been given no therapeutic treatments and had had a rather high mortality rate caused by the kidney infection. For the experiment the fish were divided equally and at random into four troughs. The fish in two troughs had sulfadiazine incorporated in the food at the rate of 12 grams per 100 pounds of body weight for 7 days, and then the sulfa was reduced to 6 grams for the remainder of the month (21 days). Sulfa therapy was stopped for the first half of the next month and then was continued at the 6-gram level for the remainder of the month. From the data in table 1, it may be surmised that the heavily infected fish are not cured by the sulfadiazine treatment, but that the treatment does have definite prophylactic value--sick fish do not eat and are therefore really not reached by the sulfadiazine therapy. When the sulfa-treated fish were sacrificed at the end

TABLE 1.--Mortality data for 192 blueback salmon infected with kidney disease, divided into 4 equal groups, 2 of which received sulfadiazine therapy

Date in 1950	Sulfadiazine therapy applied	Control ponds		Ponds given sulfadiazine	
		A	B	A'	B'
Inclusive	gm.:100 lbs. fish	mortality from disease			
June 3 to 9	12	8	2	8	8
June 10 to 16	6	6	8	5	7
June 17 to 23	6	2	3	1	0
June 24 to 30	6	2	0	1	1
July 1 to 7	0	9	2	1	1
July 8 to 15	0	3	5	0	2
July 16 to 23	6	10	10	0	0
July 24 to 31	6	4	12	0	1
August 1 to 7	0	2	2	0	0
August 8 to 15	0	1	0	0	0
Total loss from kidney disease		47	44	16	20
Accountable loss[1/]		1	4	7	9
Unaccountable loss[2/]		0	0	3	2
Total mortality in each group of 48 fish		48	48	26	31

[1/] Loss shows fish that jumped out of the troughs and some that showed no evidence of kidney disease: fish-culturists claim that these fish have a holding mortality when they are held in the hatchery too long before planting. It is of interest to note that on August 2 (near the end of the experiment) four fish died in the sulfa-treated trough B'. The fish all appeared normal, and no evidence of disease could be found on cursory examination, but perhaps drug toxicity should have been considered.

[2/] Fish that jumped out of the troughs and flopped to the floor drain.

of the experiment, all fish appeared healthy and only two showed the presence of bacteria in smears and cultures taken from the kidneys: the two had extensive kidney damage and showed that the kidney-disease organism was present but in relatively small numbers. From this it might be surmised that the sulfadiazine treatment had therapeutic value. All in all, the experiment proves that kidney disease can be controlled with sulfadiazine therapy, as treatment suppresses the spread of the infection and possibly cures some cases.

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SURVEY OF EMPLOYMENT POSSIBILITIES

A questionnaire sent by Harold Loesch, Department of Oceanography, Agriculture and Mechanical College of Texas, to the fish and game departments of the United States and Canada offers some light on the employment possibilities in fish and wildlife work. Responses to the questionnaire indicate that whereas 57 percent of the present personnel in the Provinces are working on fish, only 38 percent of the State personnel are working on fish projects. Plans for the next fiscal year, however, show recognition of the need for more fishery work within the States, as 42 percent of the new personnel hired will be for fishery projects. In the States, most of the new fishery workers will be hired for research rather than for management. In both fish and wildlife fields, the majority of the new positions in the Provinces will be in research rather than management. The increasing emphasis upon research is also indicated by the large number of States and Provinces that prefer to receive applications from men having at least the M.S. degree.

TRACY FISH-SCREENING PLANT

The Delta-Mendota Canal, an undertaking of the Bureau of Reclamation in California, has an intake capacity of 5,500 second feet. In full operation, the six pumps located about 2 miles down the canal from the intake will use about half as much power as is produced at Shasta Dam. During low flows, the canal will draw down all the water of the San Joaquin River and about half of the water of the Sacramento.

Plans for the canal did not originally include screens to prevent the entrance of fish from the rivers, but for testing purposes a pilot fish-screening plant is being installed in a temporary intake (capacity, 2,500 second feet) near Tracy. The installation includes straight vertical panels, perforated plates set on a slope with automatic cleaning devices, and a revolving or link-belt screen. Fish entering the intake will be stopped by the screens, pumped into a holding pond (the bottom of which is above the normal water level of the canal), and thence will be drained into a barge. Barge-loads of fish will be taken downstream by tug to a point beyond the influence of the water flow into the canal, and there the fish will be released to continue their way to the ocean.

The work at Tracy will include studies of fish populations of the Delta Area in the vicinity of the canal intake, as well as studies of the numbers and species of fish stopped at the screen and removed for downstream planting. It will be necessary to evaluate carefully new screens or other facilities that may be proposed, as well as the various types of screens now being installed. Attention will also be given to the determination of the best means of transporting captured fish to downstream points.

Striped bass fingerlings, fall salmon fingerlings, and catfish are expected to enter the canal in greatest numbers. The striped bass will probably appear at the time of heaviest pumping. The spring-run salmon fingerlings may pass downstream before the period of heavy pumping, but the fall chinook salmon fingerlings will probably be present during large-scale pumping. The September release of hatchery-reared fish from the U. S. Fish-Cultural Station at Coleman may be attracted to the Delta Cross Channel and thence into the Delta-Mendota Canal. As these fish will be fairly large, observers may have opportunity to check the mortality of these fish during the downstream migration.

The State of California is giving splendid cooperation to the investigations related to this fish-screening work. The Bureau of Reclamation, in charge of the entire project, is providing equipment and facilities. The Fish and Wildlife Service is supplying technical and biological personnel to direct and supervise experimental operations.

NOTES ON A BACTERIAL DISEASE OF RAINBOW TROUT IN A COLORADO HATCHERY

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AN ALARMING disease outbreak occurred among 5- to 6-inch rainbow trout at the Denver State Hatchery in August 1950. Subsequent examination showed the disease to be bacterial in nature.

Symptoms

The majority of the fish that died were bloated as if poisoned. Examination revealed that the intestinal contents were broken down to fluid masses. Numerous small hemorrhage spots were found in the oral cavity and throughout the length of the intestinal tract. The last inch or two of the intestine were highly inflamed. There were no external lesions. The spleen became bright cherry red in color. In some instances there were hemorrhage spots on the liver.

Prior to death, the fish showed much distress by darting violently about and turning on their sides. The final stage was one of lethargy. The fish settled in quiet corners of the ponds and remained motionless until death.

Treatment

Although the bacterium appears to be a virulent pathogen, there is one bright spot in the picture in that the bacterium is fairly easily controlled by the feeding of sulfamerazine.

A veterinary grade of sulfamerazine powder was fed to infected fish at the rate of 15 grams per 100 pounds of feed.

The results were startling in that the loss dropped from around 200 fish per day to only 3 or 4 in a period of 3 days' feeding. After 3 days it was found that the dosage could be dropped to 8 grams per 100 pounds of feed for 2 or 3 days and then stopped.

Small outbreaks of this disease keep recurring, but to date all have been quickly halted by the feeding of sulfamerazine.

Experiments

Bacterial cultures were obtained from the kidneys of the infected fish by disinfecting them in 1 percent roccal and cutting through the dorsal muscles to the kidney with a sterile scalpel.

The culture medium used was that developed by Dr. S. F. Snieszko (1950) containing tryptic digest of casein, yeast extract, proteose peptone, sodium chloride, and agar. A second medium containing maltose and a peptonized fish-tissue extract in addition to the above ingredients also was used. The bacteria grew well on both the media employed. No optimum temperature was determined. All incubation was done at 24° C. Pellicle formation appeared on broth cultures after prolonged incubation. The organisms collected as sediment in the broth medium. There was no staining or indicator change on the agar medium. No green fluorescent pigment was produced.

A summary of the tests run in attempted identification is as follows:

1. The organism appears to be a medium-sized (actual measurements were not obtained), Gram-negative, motile rod. Flagella staining revealed only that this was a polar

flagellate, with not enough detail to determine number or character of the flagella.

2. Colony characteristics--whitish color, glistening, circular in form, convex in elevation, with an entire margin.

3. Agar stroke--filiform.

4. Surface liquefaction of gelatin.

5. Apparently no production of indole.

6. Nitrate reduction positive on Reed and Orr medium.

7. Apparently no production of hydrogen sulfide, with the lead-acetate paper test.

8. Acid was formed in litmus milk. No curd was apparent in 10 days' incubation.

9. Tryptic digest of casein and peptone were added to the sugar media. No gas was produced in any of the sugar media. Acid was produced in maltose, glucose, d-galactose, d-levulose, d-mannitol, and glycerol. No action was recorded on sucrose, lactose, or l-arabinose.

Pellicle and ring formations occurred in maltose and glucose after prolonged incubation.

Saline suspensions of the bacteria were injected into the dorsal muscles of test-lot fish at the rates of 2/10 cubic centimeter and 5/10 cubic centimeter to verify Koch's postulate. A control lot was maintained under isolated conditions similar to those of the two test lots.

The inoculation tests resulted in 100 percent mortality in all trials. The shortest period before death was 36 hours and the longest 62 hours. The fish given the smaller dosage were the last to die. Most of the fish died within the first 50 hours. Inoculation tests were repeated after a lapse of 3 months with cultures that had been maintained in the laboratory and frequently transferred. The results were the same, as all inoculated fish died within 58 hours.

The micro-organism was re-isolated from the kidneys of dead and dying fish of the test lots and rechecked through the various sugar-reduction media with the same results.

Identification tests place the micro-organism tentatively in the genus Pseudomonas, species unknown. At first it was thought that the micro-organism might be Pseudomonas hydrophila (Reed and Toner 1942), but the sucrose and indole tests differ. Schaeperclaus (1933) speaks of an intestinal disorder of carp caused by the organism Pseudomonas punctata. The hydrogen-sulfide and indole tests differ from the action of P. punctata.

The author is not prepared to make any definite statements regarding taxonomy of the bacterium at the present time. No experiments have been run with this organism on any species of trout other than rainbow. Work is being continued, and the results will be published at a later date.

Acknowledgments

The author wishes to express his thanks to Dr. S. F. Snieszko, whose practical instruction in the culturing and handling of fish bacteria makes this type of work possible for the author; and to Mr. G. E. Steele and Mr. D. E. Owens, superintendents of the Denver and Faden hatcheries, for their cooperation and assistance in the inoculation and treatment experiments.

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FURTHER EXAMINATION OF MOUTHLESS BUFFALOFISH FROM MISSISSIPPI

The mouthless buffalofish that Jefferson C. Fuller, Jr., of the Mississippi Game and Fish Commission reported to The Progressive Fish-Culturist (volume 13, number 2, page 74) was submitted for further examination at the University of Michigan by Dr. Reeve M. Bailey. The following report from Dr. Bailey has been received by Mr. Fuller:

> "I have not yet had an opportunity to go over the deformed buffalo carefully. However, I feel confident that the injury was of long standing, probably having occurred when the specimen was still very young, possibly even from birth. It is obvious that ingestion of food could have been accomplished only through the opercular cleft. I believe that this fish must have early adapted its respiration, as well as food intake, by development of what amounts to an incurrent siphon at the upper edge of the gill cleft, followed by pharyngeal circulation of the water and expulsion near the lower part of the gill cleft. It is, I think, obvious that the food of this fish must have consisted wholly or almost wholly of plankton. It is not particularly emaciated, so I judge that it was in rather good balance with its environment. I am not certain exactly what species of buffalo you have, and this may be difficult or impossible to determine since the structure of the mouth is so important to identification of buffaloes."

SALMON-CULTURE LABORATORY AT ENTIAT

Activities of the Branch of Fishery Biology, U. S. Fish and Wildlife Service, at Leavenworth have been transferred to Entiat, Washington. By arrangement with the Branch of Game-fish and Hatcheries, the fishery biologists at Entiat will have at their disposal a complete hatchery unit for the development of improved salmon-cultural operations.

Diets developed by the Seattle Nutrition Laboratory, as well as those developed by the staff at Entiat, will be tested by practical application at the new salmon-culture laboratory. Drugs and chemicals of known effectiveness in controlling various causative factors in disease problems will be further tested by trial on a full hatchery scale at Entiat to determine proper dosages and treatments. The work at this center will also include development and testing of new fish-cultural equipment, as well as new techniques for the holding, spawning, hatching, rearing, and transporting of salmon. In addition to this work of an investigational nature, the staff will continue to conduct the in-Service training school designed to keep fish-culturists abreast of recent developments in salmon culture.

Personnel at the laboratory of the U. S. Fish and Wildlife Service at Leavenworth, Washington, recently tested an adaptation of the drip incubator for hatching salmon eggs. Trays of eggs were placed in a closed cabinet in which a high humidity was maintained by two fine jets of water striking baffles and then dripping down the sides of this cabinet.

The experiments showed that this high-humidity cabinet reduced the fungus problem, subjected the operation to fewer variables, and generally resulted in smaller loss of eggs. However, though the cabinet was excellent insofar as hatching was concerned, the moisture content was inadequate for the survival of fry.

USE OF A WETTING AGENT TO FACILITATE POND RECLAMATION

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MANY FISHERY workers have occasion to use rotenone as a means of killing fish. Whatever the purpose involved, it is obvious that the use of rotenone in fishery management is becoming more widespread with increasing recognition of its possibilities (Krumholz 1948).

Some Economic Considerations

Derris root or cube root in powdered or emulsified form is the carrying agent probably most generally used in fishery work. The active ingredient, rotenone, seldom constitutes in excess of 5 percent by weight. Emulsifiable rotenone, as now available commercially, costs about 50 percent more than powdered derris (same rotenone content), and derris in turn costs nearly twice as much as the cube. Greatly increased ease and efficiency in preparation and use afforded by emulsifiable rotenone are important advantages despite higher cost. The difficulties encountered in the field in attaining a complete suspension in water of the powdered materials are well known (Siegler and Pillsbury 1949, Krumholz 1950). Whether few or hundreds of dollars worth of chemical are involved, it is important that available funds (generally derived from sales of angling or sporting licenses) are not wasted. Therefore, the differential in cost between powdered derris root and emulsifiable rotenone is an item of more than casual interest. It appears that if aqueous suspensions of powdered rotenone-bearing roots could be readily achieved, much of the apparent advantage of using the more expensive emulsifiable rotenone would be countered.

Addition of Wetting Agent

In October 1949, the Massachusetts Division of Fisheries and Game was invited to cooperate with the Middlesex County Mosquito Control Project in developing a plan for the management of a shallow 1-acre pond located in Cambridge, Massachusetts. The object was both to obviate the necessity of drainage for mosquito-control purposes and to provide a productive "fishing hole" for recreational use by local youngsters. The writer agreed that the pond should first be treated to eliminate an existing carp population. The temperature of the water on the day of inspection, October 11, 1949, was 64° F. This suggested the desirability of doing the job early. A supply of powdered derris sufficient for the purpose was readily located. Limitations of equipment immediately at hand forced improvisation in the method of mixing. It was decided to add a wetting agent to the derris powder to facilitate the mixing of the derris with the water. At the suggestion of the clerk from whom the derris was purchased, 1 ounce of wetting agent (Ultra-Wet, product of the Atlantic Refining Company) was added to each pound of derris. Complete suspension of the derris in water consequently was achieved with astonishing ease. About a pound of this mixture was added to water in the 2-gallon tank of a discarded hand spray. The tank was tightly capped, then picked up and shaken as one would shake a bottle of milk for about 15 seconds. Almost complete suspension was attained in this time: only the largest lumps (golf-ball size), originally present in the derris as purchased, remained. These were quickly broken by

hand, and a second brief shaking served to complete the mixing.

Treatment of Small Pond

The suspension was transferred to an Indian Fire Pump and sprayed over the entire surface of the pond from shore. Dense stands of Anacharis (Elodea) were resprayed from a boat. The job of mixing and spraying the derris suspension, using one 5-gallon hand pump, was completed in three-fourths of an hour. The first fish were observed breaking the surface within 25 minutes after completion of the treatment. Several days later carp were still dying and the water had cooled below 60° F. Subsequently the pond was restocked with largemouth bass and bluegills, and no evidence that any carp remained alive has been found to date.

Thus it became apparent that the cheaper rotenone-bearing powders could be mixed readily enough with water, in the presence of a wetting agent, to eliminate much of the inconvenience and labor formerly associated with their use.

Application to Full-Scale Field Problem

On the basis of this experience, it was decided to apply the technique to a large-scale problem. This was done on September 18, 1950, when an 18-acre Cape Cod pond with maximum depth of 66 feet (Higgins Pond, Brewster, Massachusetts) was reclaimed by the writer for trout by poisoning with rotenone-bearing agents.

Some experience of the writer during former employment with TVA is in agreement with observations of Krumholz (1950) concerning the uncertain performance of cube in fishery work. However, the very low price of powdered cube and its ready availability prompted its retrial here. Because of the depth of water involved and the reputed (communication from S. B. Penick Company) superior settling qualities of emulsifiable rotenone, it was decided to employ this material in part. The latter material was applied to the surface, by means of a rotary-type gasoline pump, as a spray over depths of 30 feet or more. Powdered cube root (4½ percent rotenone content) was mixed with the wetting agent (Ultra-Wet, product of the Atlantic Refining Company) at the rate of 1 ounce to 1 pound by the washtubful. Water was then added and the mixture stirred by hand. In a matter of about one or two minutes, an effective mixture with water was achieved.

This mixture, in paste consistency, was placed in weighted burlap bags and dragged slowly at the 35-foot level to effect treatment of the deeper water. To complete the treatment, a rotary pump was used to spray additional quantities as a thin soup over the surface of water 30 feet and shallower. An occasional stirring with a short pole served to maintain the suspension of powdered root in the main supply reservoir, from which two pailfuls were removed and diluted 10 times with lake water immediately prior to each new spraying run. The entire treatment of the lake surface, employing one pump unit, required 5½ hours. Treatment of deeper water was also completed well within this time.

Settling Properties and Toxicity

Somewhat superior settling was apparent for emulsifiable rotenone. Two days after treatment, a vertical series of water samples was collected at 5-foot intervals with a Kemmerer bottle (temperature ranged at time of collection from 50° F. at 65 feet to 61° F. at surface) and tested for toxicity with test fishes. Controls were maintained in tap water. Fingerling alewives (Pomolobus pseudoharengus) were employed as test fishes. All samples were toxic but in varying lengths of time. Actual testing occurred several hours after collection of water samples. Consequently, as all samples and the control bottle were 62° F. during the testing period, variations in killing time because of temperature differentials were negated. Samples taken from the surface down to 25 feet killed test fishes in periods ranging from 30 to 40 minutes but affected the fish immediately. The 30-foot sample

required 63 minutes. Those collected at 35 feet and 40 feet killed in 40 and 58 minutes, respectively. Those at successively greater depths down to 60 feet required exposures gradually increasing from 64 minutes to 90 minutes. Control fishes in containers of similar volume had lived for 90 minutes, apparently unaffected, until the testing was terminated.

Although the emulsifiable rotenone sprayed on the surface had settled more rapidly than the powder mixture, this particular property did not appear especially advantageous. By October 3, 15 days after treatment, water samples taken at intervals of 5 feet from surface to bottom (ranging in temperature at collection from 54° to 62° F. but again equated for testing purposes) were about equally toxic to test fishes (alewife fingerlings) on the basis of killing time required. This apparently ranged from 11 to 22 minutes after immediate violent reaction. Controls again were unaffected. By December 7, water samples taken at 10-foot intervals from surface to bottom apparently failed to affect test fishes (in this instance fingerling golden shiners, Notemigonus crysoleucas) during a 2-hour period of exposure. The temperature of all water samples, although 47° F. when collected, was unavoidably equated during testing at 34° F.; the depressing effect of this much colder temperature on toxicity of the residual rotenone cannot, of course, be wholly discounted.

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An undeclared war apparently continues between dragonfly nymphs and trout. As meat-eaters, nymphs and trout are frequently found competing for the same type of food. Aside from this competition, they do not hesitate to eat each other. The trout snap up and eat large numbers of nymphs when they are abundant, and the nymphs are voracious eaters of young trout. Most fish-culturists, claiming that the nymphs are responsible for great losses of young hatchery-reared trout, give active aid and sympathy to the trout and do everything possible to control the aggressive nymphs.

CHLORINE-REMOVAL UNIT AT FULL-SCALE OPERATING HATCHERY

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FOR THE 25 years of its operation prior to March 1950, the U. S. Fish-Cultural Station at La Crosse, Wisconsin, found the city water supply quite satisfactory for trout-cultural purposes. When the city began to chlorinate the water, however, it became necessary for the station to install a chlorine-removal unit. To our knowledge, this is the first time that a full-scale operating hatchery has been supplied with water passed through a unit of this type.

The La Crosse Station consists of two units, the main hatchery and a substation. The main hatchery has 64 troughs, 5 tanks, and a 5-tank aquarium; at peak operation, it utilizes about 200 gallons of water per minute. Brook trout, rainbow trout, and brown trout eggs are received at the station--egg capacity, approximately 800,000 to 900,000--from December to January. Trout are reared to No. 2 or No. 3 fingerling size--average seasonal production, approximately 700,000 fingerlings--and distributed to other rearing facilities in May and June. Bass and bluegills from a nearby hatchery are held in tanks and troughs during the distribution season in August. The substation has 32 troughs and 2 tanks.

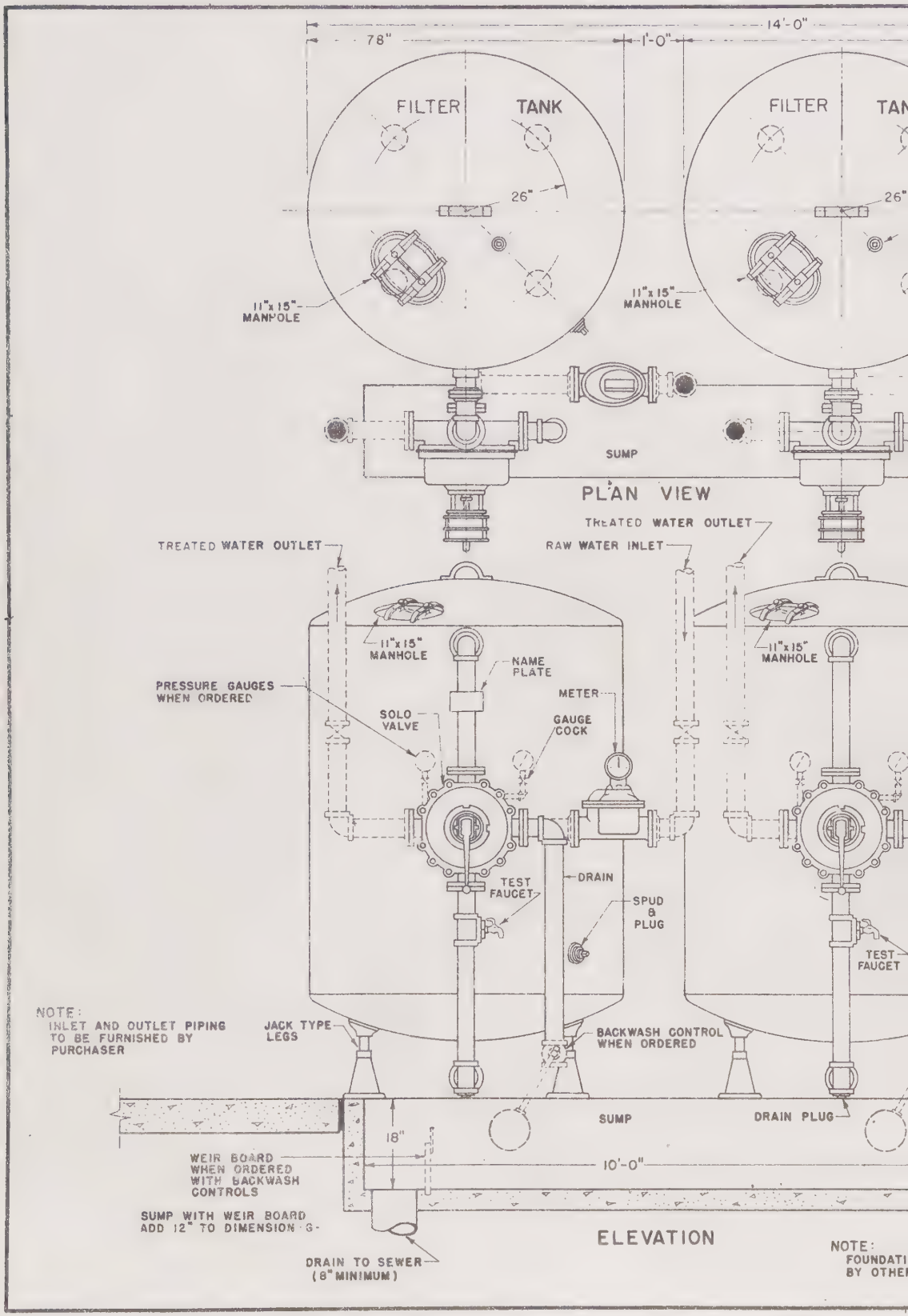
Because of an unexpected advance in the date of the first chlorine treatment, the hatchery had but 3 days' notice before the chlorination began. Efforts to neutralize the chlorine with a chemical drip system failed. About 10 percent of the No. 2 brook trout fingerlings at the substation died during the night after chlorination started; the remaining fish in this unit were removed at once, and it was closed indefinitely. The main hatchery, much farther from the chlorine source, benefited also from better adjustment of the sodium-thiosulfate drip system. The capacity load of No. 2 brown, rainbow, and brook trout fingerlings in this hatchery showed little mortality until noon of the day after the first chlorination. In the afternoon, however, a small but steady loss began to occur. At this time the city water was shut off and the hatchery was supplied by pumping from the deep well at the station. As it soon was evident that this water contained hydrogen sulfide in almost lethal amounts, water was pumped thereafter from the Mississippi River until the fish could be moved.

A permanent chlorine-removal unit was installed in order that the station might be continued in production.

Basically, the equipment consists of an activated carbon filtration unit housed in two steel tanks and the necessary piping, valves, and drain facilities. Each tank has a flow capacity of 105 gallons per minute, the total unit capacity being 210 gallons per minute. Each tank can support normal operation of the hatchery while the other tank is being back-washed. There are no moving parts; all action depends on water pressure. The only servicing needed is the daily back-washing recommended by the manufacturer to prolong the life and efficiency of the filter element. The exact life of the filter element is not known, but the activated carbon element is expected to be serviceable at least a year under present conditions at La Crosse.

Since installation of this equipment (total cost here, $7,115) on January 25, 1951, the La Crosse Station has been operating at near capacity again.

The drawing (opposite) is reproduced through the courtesy of the successful bidder for this contract.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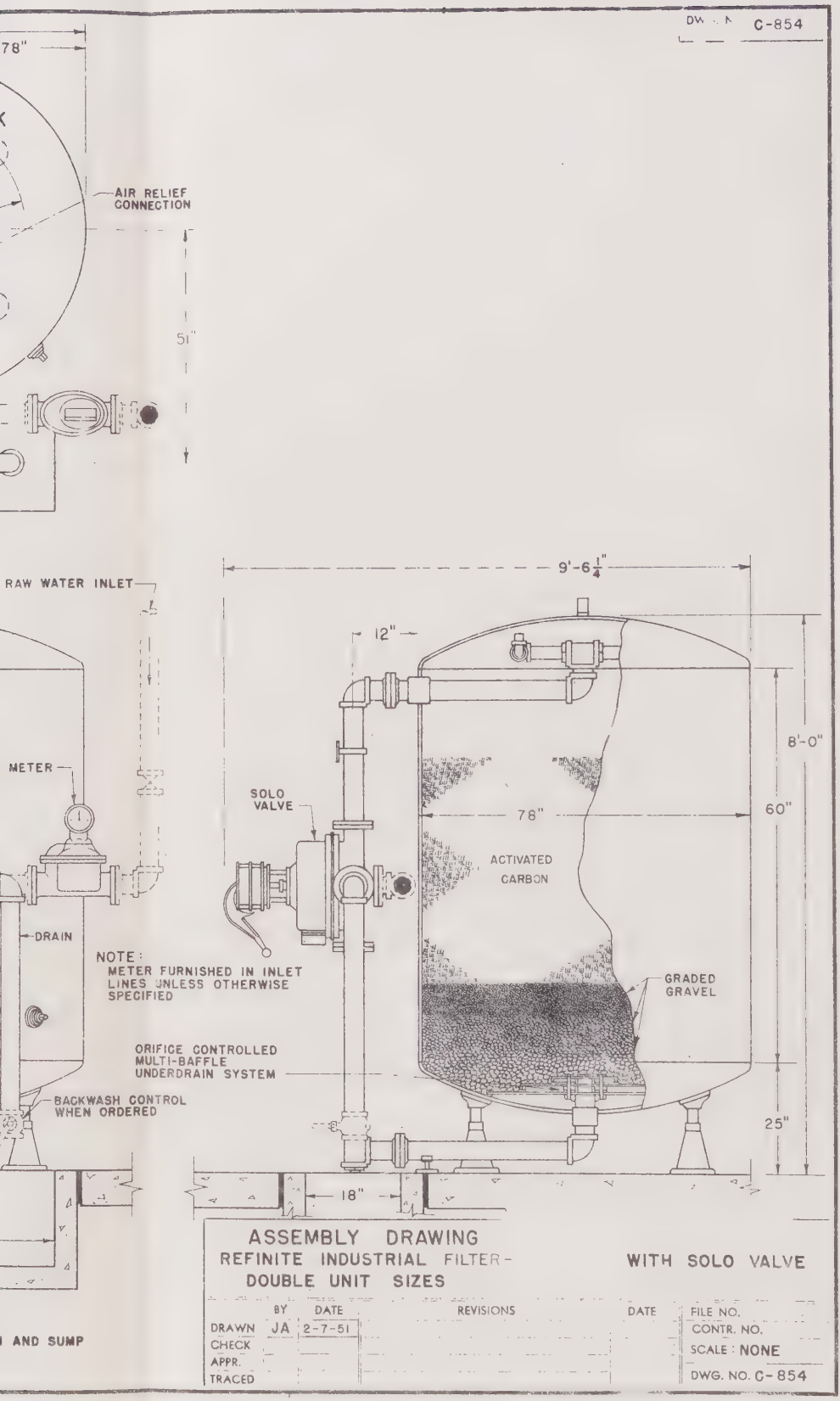
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SUGGESTIONS FOR IMPROVING THE COLLECTION OF FISH WITH ROTENONE

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ROTENONE MATERIALS are now widely used in fishery management and research. Many authors have reported incomplete kills during attempts to eradicate undesirable populations. Others have noted that all poisoned fish did not float on the surface and that recoveries of marked fish were incomplete.

In the present authors' field work on farm ponds, rotenone was applied both to eradicate populations and to check population estimates made by the marking-and-recovery technique. In 1949, to eradicate black bullheads (Ameiurus melas) from four ponds, cube powder containing 4.6 percent rotenone was used at the recommended concentration of 0.5 p.p.m., plus an additional 50 percent because the powder was known to be fairly old. It was assumed at the time that the kills were complete, especially since the pick-up at one of the ponds showed 517 pounds of bullheads per acre. Subsequent reports from the landowners, however, indicated survival of some fish. The repoisoning of one of these ponds in 1950 produced a pick-up of 607 adult fish from the one-half acre of surface, indicating a fairly large survival from the first poisoning operation.

In checking population studies during 1949 and 1950, recoveries of marked fish were always incomplete and ranged from 22 to 65 percent. Similar results have been reported by Carlander and Lewis (1948) and Ball (1948). The numbers of fish that came to the surface soon after treatment were quite variable, and some evidence suggested that the concentration of rotenone used might affect the number of fish that could be recovered. In two ponds treated with 1.25 p.p.m. of fresh derris powder, it was noted that relatively little surface activity occurred. Those fish that did break the surface did so but briefly and then disappeared. Recoveries of fish by thorough seining and dip-netting on the day of treatment were disappointingly small. Proof of a substantial kill was, however, apparent by the third day, when bloated carcasses of fish appeared in quantity. At both of the ponds the pick-up of bloated fish was almost as great as that on the day of poisoning. Many of the bullheads appeared only when bloated, a point which differed from previous experiences. In the one pond, no large bass were picked up on the first day: a number of them appeared in the collection on the third day after treatment.

A series of experiments was therefore performed to study some effects of various concentrations of rotenone. Three species of fish--orangespotted sunfish (Lepomis humilis), green sunfish (L. cyanellus), and black bullheads (Ameiurus melas)--were brought into the laboratory, where controlled tests were conducted in glass aquaria containing 20,000 cubic centimeters and glass jars containing 3,000 cubic centimeters of water. Tests were run in duplicate or triplicate; one or

From Project No. 37 of Iowa Cooperative Fisheries Research Unit, sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College.

more tanks were used as controls. Tanks were filled 24 hours prior to the test to allow adjustment to room temperature of 65° to 70° F., and 10 to 12 fish were added 12 hours later. Comparisons of the effect were based upon the time at which the following behavior characteristics were observed:

1. No response to mechanical stimulus when touched with a probe. This stage is comparable to the time when fish become vastly more susceptible to capture with a seine.
2. Complete loss of equilibrium.
3. Little or no movement of the body, fins, or gill covers. This observation was reasonably close to the actual point of death and could be readily timed--which was not true of the actual point of death.

Before the testing of different concentrations, some experiments were run to measure the effect of aging on rotenone powders. This information was particularly desired because of the unsatisfactory results with old cube powder used in 1949. Krumholz (1950) speaks of deterioration occurring in cube but not in derris materials. Four cube preparations were accordingly compared: fresh emulsifiable rotenone at 5 percent, fresh powder containing 3.75 percent rotenone, aged powder with 4.6 percent rotenone that had been in storage for 4½ years in sealed paper bags, and aged powder with 4.3 percent rotenone that had been in storage in a burlap sack for a long but unknown period of time. A manufacturer's chemical assay of the first lot of aged cube indicated deterioration from the original 4.6 percent to 3.77 percent, or a loss in toxicity of 18 percent in 4½ years. The suspensions were made on the basis of 1.0 p.p.m. of 5-percent rotenone material, assuming that the rotenone concentrations were as listed on the storage containers.

Fish exposed to emulsifiable rotenone consistently showed behavior condition No. 1 (no response to mechanical stimulus) sooner than fish exposed to the other preparations. Fish exposed to suspensions of the fresh powder took 1.6 as much time as did those exposed to the emulsion; fish in suspensions of the powder aged in the paper bag took 2.4 as much time; and those exposed to suspensions of the aged powder from the burlap sack took 2.8 as much time. Comparison of the time intervals up until the third behavior condition (little or no movement) gave the same order of ranking. These relative times were 1.0 for the emulsifiable rotenone, 1.3 for the fresh powder, and 2.0 for the aged powder stored in the paper bags. The chemical stored in the burlap sack is not included because it did not give complete kills.

Gunther (1943) and Leonard (1939) have indicated that exposure to light reduces rotenone toxicity. A series of tests with dry cube powder exposed to normal room light for periods up to 31 days showed no significant loss in toxicity.

Another series of experiments was run to determine whether collection of fish after treatment of a pond might be improved by adjusting the concentration so that the fish remained active but under the influence of the chemical for longer periods of time. Concentrations tested ranged from 0.1 to 10.0 p.p.m. of 5 percent rotenone.

Concentrations of 0.1 p.p.m. killed some but not all of the orangespotted and green sunfish and did not noticeably affect the black bullheads. All sunfish were killed by 0.25 p.p.m., and some of the bullheads were affected but did not die. All individuals of the three species were killed by concentrations of 0.5 p.p.m. and greater. The length of the time from start of the test to any of the specified responses decreased in regular fashion as the concentration of toxic material increased. (See figure 1.) The orangespotted sunfish were quite consistently more susceptible to poisoning than were the green sunfish or the black bullheads; the green sunfish did not show the reactions until about 1.5 times as long after treatments as the orangespotted sunfish, and the bullheads 4.0 times.

At the levels of rotenone greater than 3 p.p.m., a majority of the sunfish displayed a violent type of reaction as described by Leonard (1939). Occasional individuals gave this type of reaction in concentrations as low as 1.0 p.p.m. In

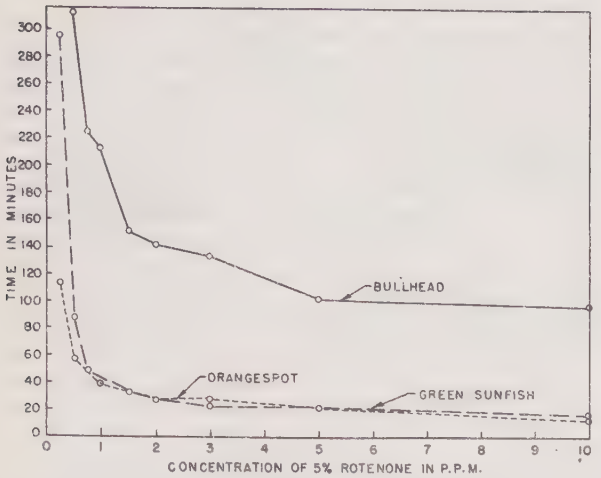

FIGURE 1.--The effect of rotenone concentration upon the time required to render fish motionless.

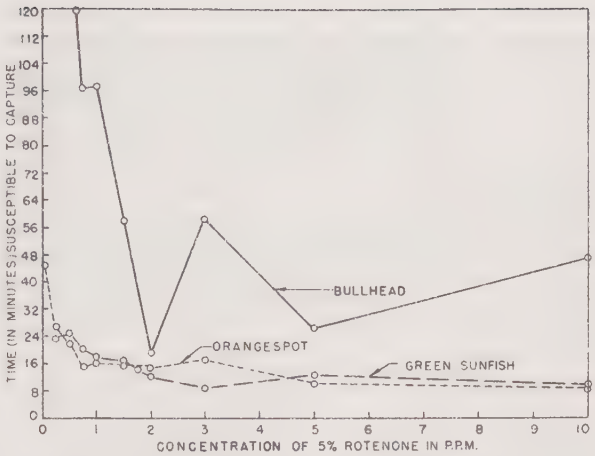

FIGURE 2.--The effect of rotenone concentration upon the time that the fish remain susceptible to capture.

no instance did any of the sunfish float at the surface near death, but approximately two-thirds of the bullheads did so. In reacting, the orangespotted sunfish always rose to the surface and broke water but the green sunfish did not always do so in the weaker concentrations. Bullhead response to rotenone was always greatly delayed, the fish rising to mouth the surface while moving slowly about. A few of the bullheads managed to recover after showing definite response to rotenone. Only one green sunfish was observed to recover after showing symptoms of poisoning.

To increase the collection of fish after treatment with rotenone, the authors have found it advisable to seine as the fish become affected. The time between the first and second behavior characteristics is the period when the fish can be most readily captured in this manner. Concentrations of 1.0 p.p.m. of 5-percent cube and below resulted in relatively long periods when fish were highly susceptible to capture, whereas concentrations above 1.0 p.p.m. gave shorter periods of susceptibility. (See figure 2.)

Field tests have not been made yet, but it is suggested that relatively light doses of about 0.25 p.p.m. be applied for the collection of sunfish and species of similar sensitivity, followed by further dosage bringing the concentration up to 1.0 p.p.m. to ensure a kill of the bullheads. Heavier dosages may result in a less complete collection of fish, as they will die and sink more rapidly. Because older rotenone preparations may have lost part of their toxicity, fresh powder should be used when possible.

Acknowledgments

The authors wish to express their appreciation to Dr. K. D. Carlander for advice and encouragement throughout this work. The contributions of Mr. H. J. Chandler and Mr. J. G. Erickson, who assisted in the field, and of Dr. C. H. Richardson and Mr. W. D. Fronk in providing suggestions and materials, are sincerely acknowledged. The John Powell and Co., Inc., ran the chemical assay of one of the materials used.

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As the weather becomes warmer, maggots should be fed, these most disgusting, but to the fish culturist most valuable, creatures being the nearest approach to the natural food of the trout that can be obtained. Several methods have been devised for procuring them. In one, a box is constructed, three feet high and two feet square; in the bottom is placed a drawer, about four inches deep, and above this a strong wire grating, the wires being about an inch apart. Numerous holes, one-half inch in diameter, are bored in the sides above the drawer, and the whole is surmounted by a cover. In this, above the grating, any offal is thrown. The maggots on attaining their full size drop through the grating to the drawer beneath, which can at any time be removed and its contents emptied into the pond. This apparatus has been christened, by a facetious visitor, the Maggotometer.

But the emptying of the drawer is by no means a pleasant task, and the old-fashioned method of suspending offal from a wire directly over the pond, thus allowing the maggots to drop, as it were, directly into the mouths of the fishes, is perhaps preferable. ... The importance of this variety of food can not be over-estimated. It is the nearest approach which we can obtain to the insects which form so great a part of the food of trout in streams, and even if some inconvenience to the eyes and nostrils is occasioned by it, must be in some way supplied. During one season, disgusted by the odor, we depended upon an increased supply of meat as food for our young trout, omitting entirely the maggots; but the small size attained by the fishes during the year, less than half that of the preceding, when less meat and more maggots were fed, warned us not to repeat the experiment.

--J. H. Slack, "Practical trout culture." New York, 1872.

PRACTICAL GILL NET SIZES FOR SAMPLING AVERAGE CONNECTICUT LAKES

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THIS PAPER is based on information collected in the course of 22 lake and pond surveys conducted by the Connecticut State Board of Fisheries and Game during the summer of 1949.

The data shown here are presented in an attempt to aid those who are unfamiliar with gill nets in choosing mesh sizes suitable for lake or pond survey work. The graphs were originally prepared to show the mesh sizes necessary to obtain an adequate number of various-sized fish for age and growth studies. It was our desire to discover the mesh sizes which we could most profitably use to obtain a reasonable number of fish and at the same time keep to a minimum the amount of net used. We do not mean to imply that overnight net sets can be used to establish populations. As we use gill nets at the present, they are mainly a tool employed to obtain specimens for determination of age and growth.

During 1949, the following types of nets were used. These nets were of Sea Island cotton and hung on a 2 to 1 basis. We use 2- by 1½-inch corks for floats and 6-inch rings of ¼-inch galvanized wire as weights. Rings and corks are hung 6 feet apart. All mesh sizes are given in stretched measure.

(1) 1½-inch mesh, 60 feet long by 4 feet deep, 90/6 thread.

(2) 2½-inch mesh, 200 feet long by 8 feet deep, 60/6 thread.

(3) 2¼-, 2½-, and 2-3/4-inch mesh, 50 feet of each connected to form one continuous 150-foot net, 8 feet deep, 60/6 thread.

A small amount of 3- and 4-inch mesh was also used. The 3-inch mesh took no chain pickerel, two smallmouth bass, two golden shiners, and two yellow perch. The 4-inch mesh took no fish of the species already named. It appears that 3- and 4-inch mesh are too large for survey work in average Connecticut lakes. The sum of the overnight net sets was 13,842 square yards; the total catch, 1,038 fish, or 1 fish per 13.33 square yards of net set. An average of 629 square yards of net was set in each lake and pond; the average catch was 47.6 fish.

The graphs shown in figures 1 and 2 are self-explanatory. They show the increase in average total length and average weight that accompanies each increase in mesh size. In figure 2, chain pickerel do not show this increase in weight from 2½- to 2-3/4-inch mesh; this is no doubt due to lack of data, as only 16 fish were taken in the latter mesh size.

The graphs in figure 3, based on 35 specimens, show the percentage composition of the catch of smallmouth bass by 1-inch intervals for each of the four mesh sizes. Both species of black bass that we are concerned with, and the smallmouth in particular, are very difficult to take in gill nets. These graphs are based on too few specimens to draw any definite conclusions. However, it does appear that 2¼-inch mesh could be eliminated. This mesh size took only seven fish, and all sizes were also represented in the 2½-inch and 2-3/4-inch mesh. Though 1½-inch mesh did not take any smallmouth bass, it is still desirable to use this net size. If yearling bass are to be

taken at all in gill nets, 1½-inch mesh is probably the mesh size that will take them.

The graphs in figure 4, based on 73 specimens, show the percentage composition of the catch of chain pickerel by 2-inch intervals for each of the four mesh sizes. This species is also represented by a rather small number of specimens, but from the available data it appears that 1½- and 2½-inch mesh would take an adequate number of various sizes of pickerel. All sizes of fish taken in the 2½- and 2-3/4-inch mesh are duplicated by the 1½- and 2½-inch mesh.

The graphs shown in figure 5 are based on 181 yellow perch and show the composition in percent of the catch by 1-inch

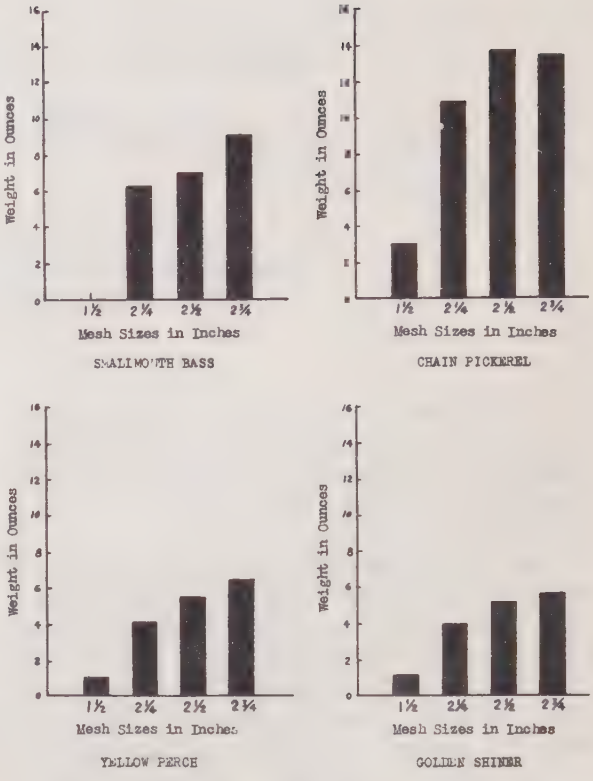
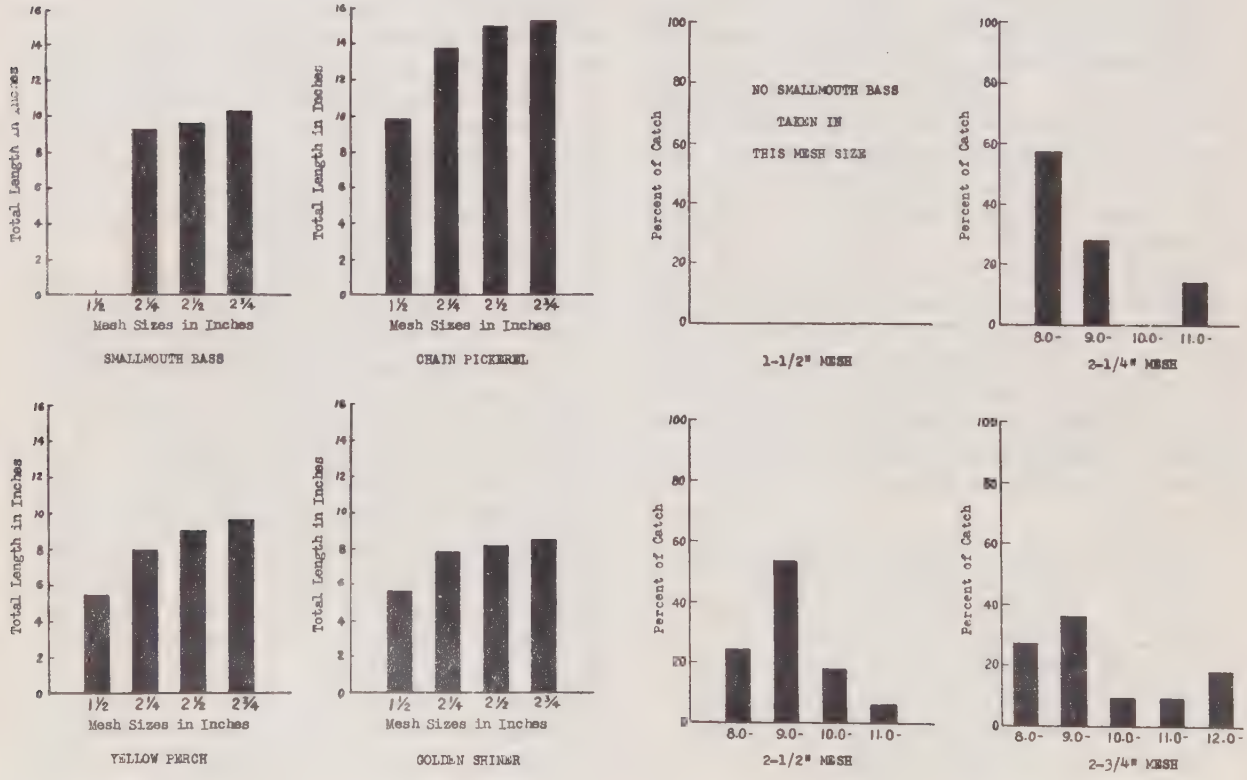


FIGURE 1.--Relationship of net sizes to average total length.

(second column)

FIGURE 2.--Relationship of net sizes to weight.

FIGURE 3.--Composition of total catch of smallmouth bass by 1-inch intervals.



intervals in fish size. The absence of 6-inch fish from the catch was no doubt accidental. It appears that 2¼-inch mesh could be replaced by 2-inch mesh. The available data seem to indicate that this would result in a catch, for that mesh size, made up largely of 6- and 7-inch fish. The data indicate that the information obtained by the 2-3/4-inch mesh is duplicated more efficiently by the 2½-inch mesh. It appears that this species could be most effectively taken with 1½-, 2-, and 2½-inch mesh.

The four graphs in figure 6 are based on 749 golden shiners. These graphs show that approximately 90 percent of the catch in 2¼-, 2½-, and 2-3/4-inch mesh is composed of 7- and 8-inch fish. In this

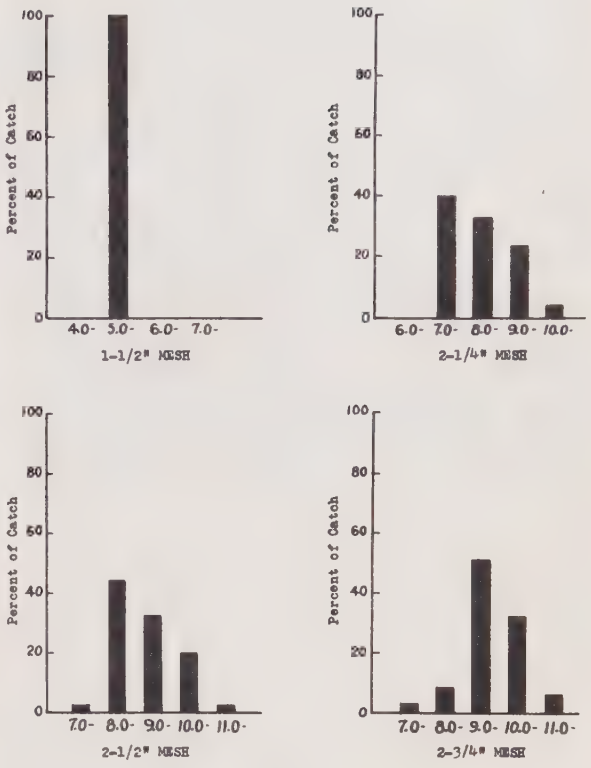
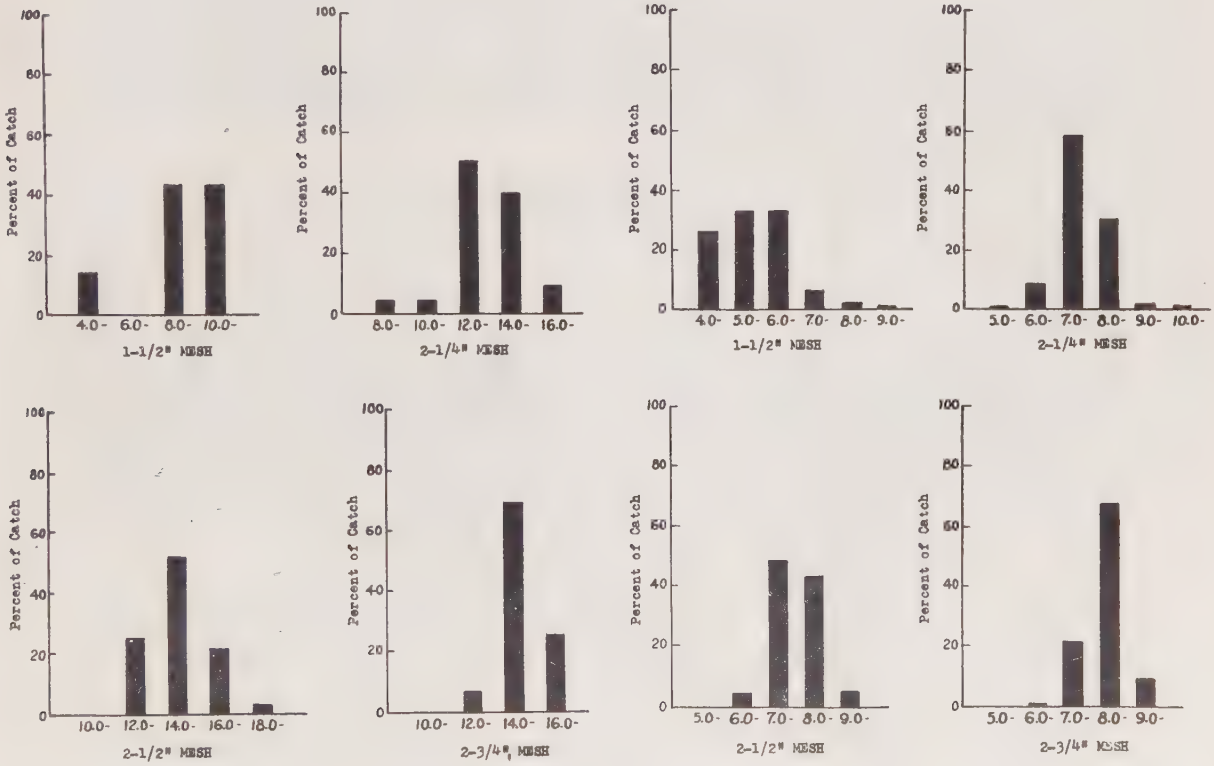


FIGURE 4.--Composition of total catch of chain pickerel by 2-inch intervals.

(second column)

FIGURE 5.--Composition of total catch of yellow perch by 1-inch intervals.

FIGURE 6.--Composition of total catch of golden shiners by 1-inch intervals.



particular species, the graphs seem to indicate that 1½-inch mesh and any one of the other three mesh sizes would take an adequate range of sizes. Replacing 2½-inch mesh with 2-inch mesh would probably result in a catch, for that mesh size, made up largely of 6- and 7-inch fish. Probably the ideal nets for this species, based on the data shown, would include only 1½- and 2½-inch mesh.

On the basis of these data, it is our opinion that the ideal gill netting for survey work in Connecticut lakes would consist of 1½-, 2-, 2½-, and 2-3/4-inch mesh. For most species, 2-3/4-inch mesh merely duplicates the data obtained by the 2½-inch mesh; however, it does take a larger range of sizes of smallmouth bass, and this is one of our most important lake game-fish. It is our belief that a nearly ideal net for our purpose would be composed of 50 feet each of 2-, 2½-, and 2-3/4-inch mesh and 15 feet of 1½-inch mesh sewed together to form one continuous gang. For most efficient use, these nets should be available in 4-foot and 8-foot depth for use in shallow ponds and deep ponds. Present available data seem to indicate that these types of nets will result in a more uniform spread in sizes of fish taken and will cut down slightly the amount of net needed to obtain an adequate number of fish for age and growth studies.

The inroads of the sea lamprey upon fish life in the Great Lakes may go down in history as comparable to the destruction ensuing from the introduction of the English hare into Australia, a classic example of habitat being overrun by a species having a high reproductive potential and not controlled by predation, disease, or competition from the endemic forms.

Backswimmers and water-boatmen at times destroy large numbers of fry. Because these insects must come to the water surface to breathe, an application of various oils--such as kerosene or diesel-fuel oil at approximately 10 gallons per acre--spread over the entire surface of an infested pond is an effective control measure. Dragonfly nymphs, which use oxygen dissolved in the water, are unaffected by surface oils.

CAN WE ESTABLISH A STANDARD SYSTEM OF MEASURING LENGTHS AND WEIGHTS OF FISHES?

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OPINIONS ON this subject were obtained by letter and interview from 20 persons in 13 States and Provinces, mostly in the Midwest. The questions asked were:

1. What method (English or metric) are you now using?
2. Do you prefer standard, fork, or total length?
3. Do you prefer "K" or "C" values for determining condition?
4. Would you be willing to change, in the interests of standardization, if you differ from the majority?
5. Do you approve or disapprove, in the interest of standardization, of Hile's method?
6. What suggestions do you offer to settle the question?

As seen in table 1, 50 percent replied that they now use or prefer the English-in-tenths system, 10 percent prefer the metric, and 40 percent use both. In the category using both, there was a wide variation of practices. Most of those in this group made measurements in the metric system but converted to the English-in-tenths system for publication in popular articles. Half of those using both systems included the ichthyological studies they were doing in universities.

The greatest agreement concerned the length measurement, as 80 percent preferred total length, 20 percent preferred fork length, and none preferred standard length (to base of caudal fin). The total-length measurement as used here refers to the length to the tip of the caudal with the two lobes squeezed together. Some were of the opinion that if this measurement were adopted for fishery research, it should be used for all types of fish study.

The question on "C" or "K" for expressing condition was included because it involved the questions of metric or English and standard length or total length. The K factor is used in expressing relation of weight in grams to standard length in millimeters, while C expresses the relation of weight in pounds to total length in inches. Thirty-five percent preferred C, 35 percent preferred K, and 30 percent either had no preference or preferred some other system. Several preferred to use K and at the same time preferred the use of inches and tenths. This apparent inconsistency results from collecting and analyzing the original

TABLE 1.--Summary of responses to questionnaire

Preference for			Do you desire uniformity?	Are you willing to change?
English or metric	Total, fork, or standard length	"C" or "K" value		
50% English	80% Total	35% "C"	70% Yes	50% Yes
10% Metric	20% Fork	35% "K"		35% No
40% Both	0 Standard	30% Other		

data in the metric units but converting to the English-in-tenths system for publication. Such a possibility was not anticipated and constitutes an inherent flaw in the questionnaire.

Seventy percent desired uniformity; the other 30 percent either gave no answer, said that it would be difficult to get, or said that it would never be settled. Fifty percent wished uniformity sufficiently to change to any system agreed upon by the majority.

Sixty-five percent approved the article by Hile (1948), while the other 35 percent either agreed with reservations or did not agree.

Conclusions

This study has shown the problem of establishing a standard system of procedures in fishery work to be complicated and important enough to study until all aspects have been viewed and opinions expressed. The author had much more definite opinions at the start than now. It appears that the English-in-tenths system and total lengths might rather easily win in a group of midwestern fishery men. A similar trend also appeared in the non-academic group sampled by Knapp (1950). In the present study the marine-fisheries group is not represented, and inasmuch as most of them use the metric system and standard length, they should have a voice in the decision if we are to have uniformity. There is probably more reason for the use of these methods in marine fisheries because of the need to compare results with those of our non-English-speaking neighbors who are often studying the same populations.

If we admit that marine workers should use a system different from our own, we get into difficulties again when considering what to do with brackish-water fishes and anadromous and catadromous fishes.

Hile (1948), in recommending English units "for articles of a popular or semi-popular nature" and both systems for more formal publications, appears to recognize the inevitability of conversion. Carlander (1945) and others have shown that a large factor of error often accompanies conversion from one type of length measurement (standard, fork, or total) to another. Besides, it is a very inconvenient and time-consuming obstacle. The difficulties might not be so great if we all took our measurements in the metric system, as suggested by R. W. Eschmeyer, Carlander, Hasler, and others, and converted for the popular articles. Our condition factors then would be in the same terms (K) and much wasted effort would be saved.

We should all give serious thought to the question of standardization, which the American Fisheries Society has taken up for study.

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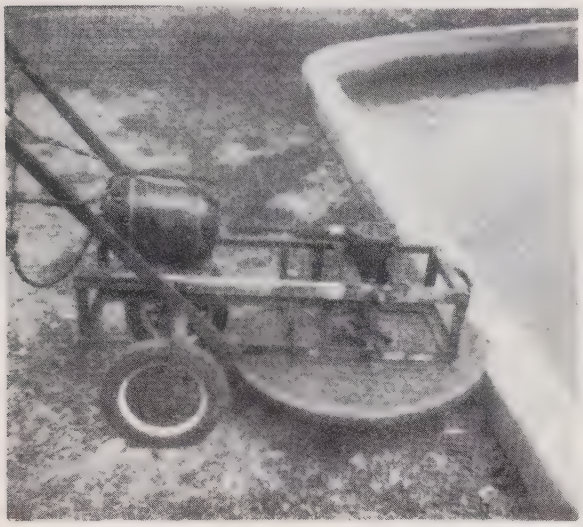

POND-SCRUBBING MACHINE WITH SINGLE BRUSH

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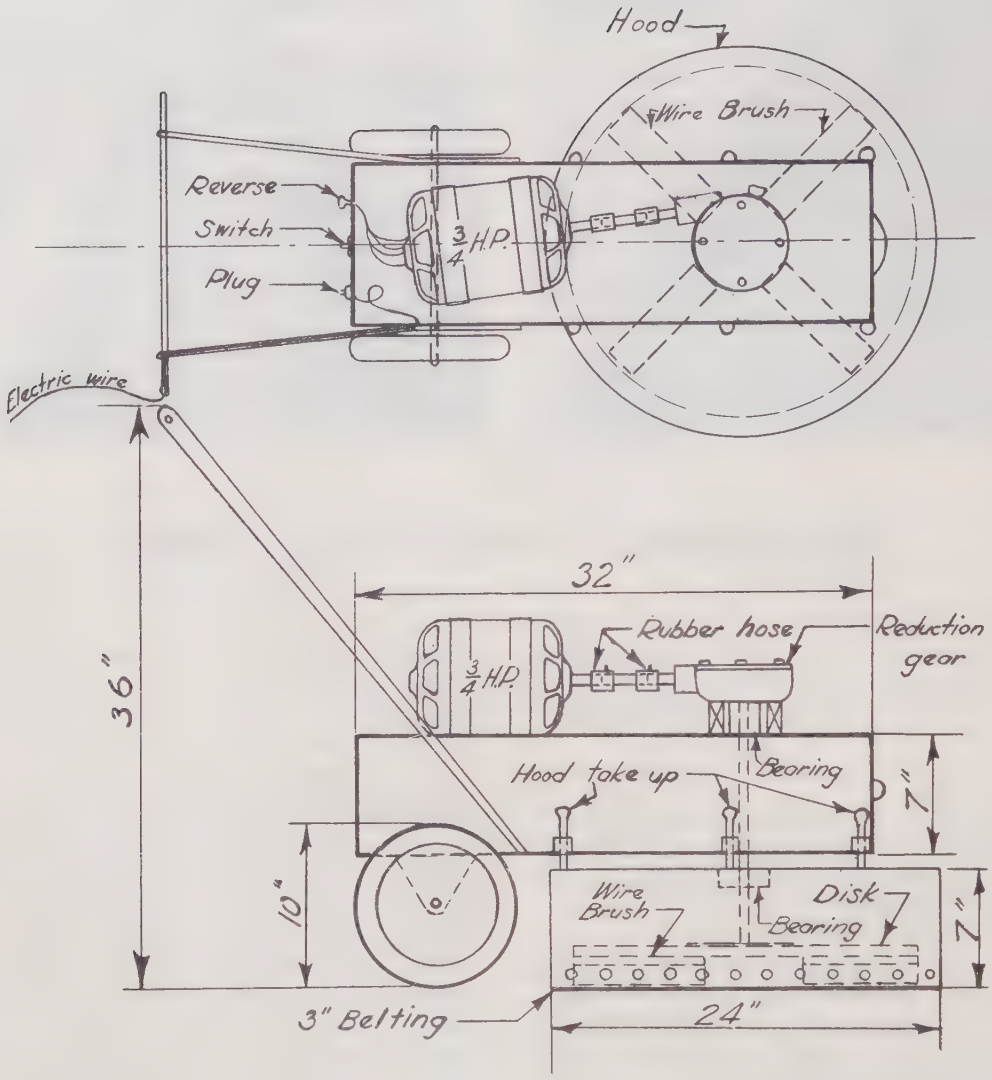
Miles City, Montana

THE MECHANICAL pond-scrubber now in use at the U. S. Fish-Cultural Station at Creston, Montana, has proved to be a saver of time and labor.

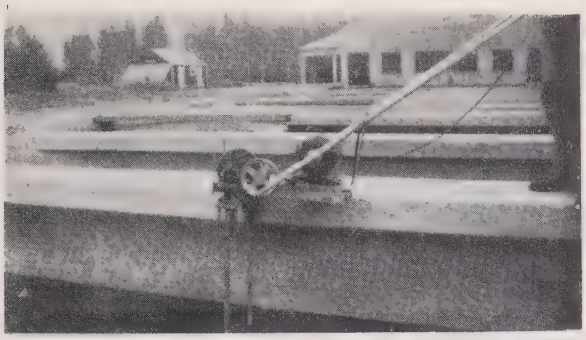
The station at Creston has 12 raceway ponds and 10 Foster-Lucas ponds. Using this machine, one man can scrub the bottoms of all these ponds white in 20 hours, whereas the task would require 106 hours if it were done manually. This scrubber removes all the slime and algae from the pond bottoms, making them as white and clean as the day the ponds were built. The machine may be used while the fish are in the ponds, as the brushes are completely covered by a hood.

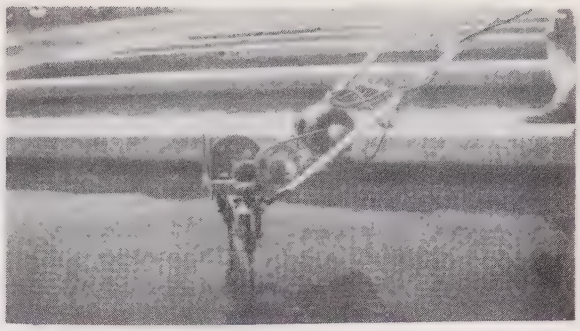
Although a good scrubbing about once a month keeps the ponds in good condition and reduces the disease rate of the fish, the best results have been obtained by scrubbing an empty pond, letting it dry for three days, and then painting it with a solution of copper sulphate (2 pounds to 1 gallon of water). It is advisable to let the copper-sulphate solution remain in the pond for one day and then rinse the pond thoroughly to remove the solution. This procedure, in addition to a monthly scrubbing, has given excellent results at the Creston station.

The machine is powered by a reversible 3/4-horsepower electric motor of 3,500 revolutions per minute. The reversible motor is necessary so that the action can be reversed frequently in order to conserve the steel brushes and keep them sharp. The gear-reduction box has been taken from the steering gear of a 1929 Chevrolet, but any steering box that revolves completely would be feasible. The reduction is about 1 to 20, which makes the revolution of the brushes about 175 revolutions per minute. The shaft from the motor to the gear-reduction box has been cut in two places and fastened together with pieces of rubber hose which take the place of universal joints. The 3/4-inch shaft from the reduction box to the 21-inch wooden disk that holds three brushes is attached to the disk



by a universal joint. This is necessary so that the brushes will be level on the pond bottom at all times. The guard hood over the disk is mobile, moving back and forth or up and down, so that the bottom edge (made of 3-inch belting) slides along the pond bottom. The hood, 30 inches in diameter, is made of perforated tin so that the water can circulate freely. The depth of the hood is determined by the size of the wheels used. The wheels used on this machine had pneumatic tires.





POND-SCRUBBING MACHINE WITH DOUBLE BRUSH

Harold G. Kronholm
U. S. Fish and Wildlife Service
Entiat, Washington

THE DRUDGERY of scrubbing algae from cement ponds with long-handled deck or wire brushes has caused the writer, like many another fish-culturist, to give much thought to finding better means of doing the job. The scrubbing machine described herein, produced by this fish-culturist largely from surplus materials, has proved satisfactory in most respects at the U. S. Fish-Cultural Station at Entiat, Washington.

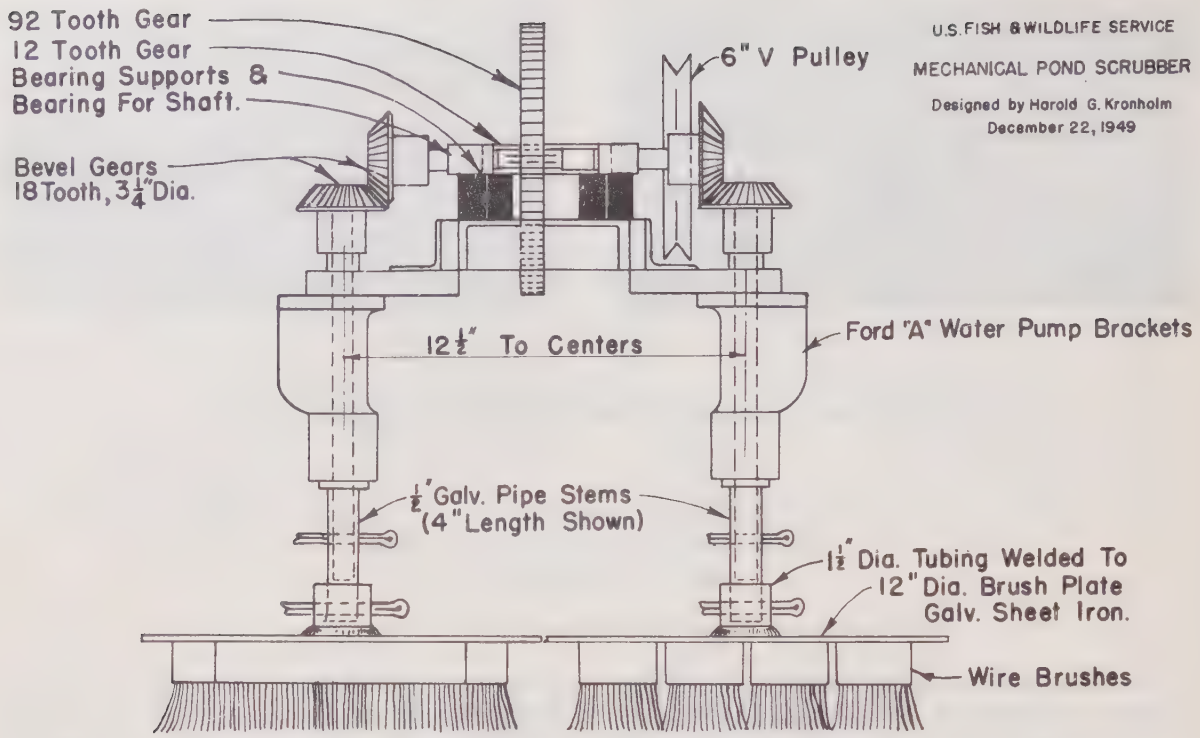
Among the desirable features of the present model are lightness and compactness. It weighs 42 pounds without motor and brush units; assembled, it weighs about 80 pounds. It must be lifted over four obstacles in each Foster-Lucas pond, but one man can handle the machine with very little effort. The machine is easily portable, being carried from the hatchery to the ponds in three parts--motor, drive unit, and brush unit. It is quickly assembled or dismantled by the use of large cotter keys at the upper end of the brush stems.

The machine is easily maneuvered, being operated from the pond walks regardless of the depth of water. Earlier one-brush models failed because of the tendency of the brush to run out from under the weight of the power unit. The present two-brush machine overcomes this fault by the opposed rotation of each brush counteracting the side motion of the other. Steering is accomplished by tipping the machine slightly to one brush or the other and thus producing side motion in the desired direction.

In practice, it has been found best to clean a quarter of a pond at a time, owing to the turbid condition of the water when heavy growth is removed. This machine makes it possible to clean in about 1 hour a small Foster-Lucas pond which ordinarily required 6 to 8 man-hours of labor with wire brushes. This does not take into

MATERIALS AND PARTS

2	pieces	light angle iron, 22" x 1½" x 1½"
2	"	" strap iron, 4-5/8" x 1" x 1/8
1	"	" angle iron, 4-5/8" x ½" x ½"
2	"	L-shaped brackets, 5-3/4" x 2" x 3½"
1		6-inch V pulley
1		12-tooth pinion gear, 1½" diameter
1		92-tooth drive gear, 8" "
4		18-tooth bevel gears, 3" "
4	feet	cold-rolled shafting, 5/8" "
12	"	galvanized water pipe, ½" "
2	disks	14-gauge sheet iron, 12" "
2		Ford A water-pump brackets
1		brush-stem spacer or spreader
4		bearing brackets or pillow blocks, with bearings or bushings for 5/8-inch shaft.



consideration the great difference in physical exertion expended. One man can clean several ponds without too much discomfort. Scrubbing once a week seems adequate. The fish keep well away from the machine, and no increase in mortality from its use has been noted.

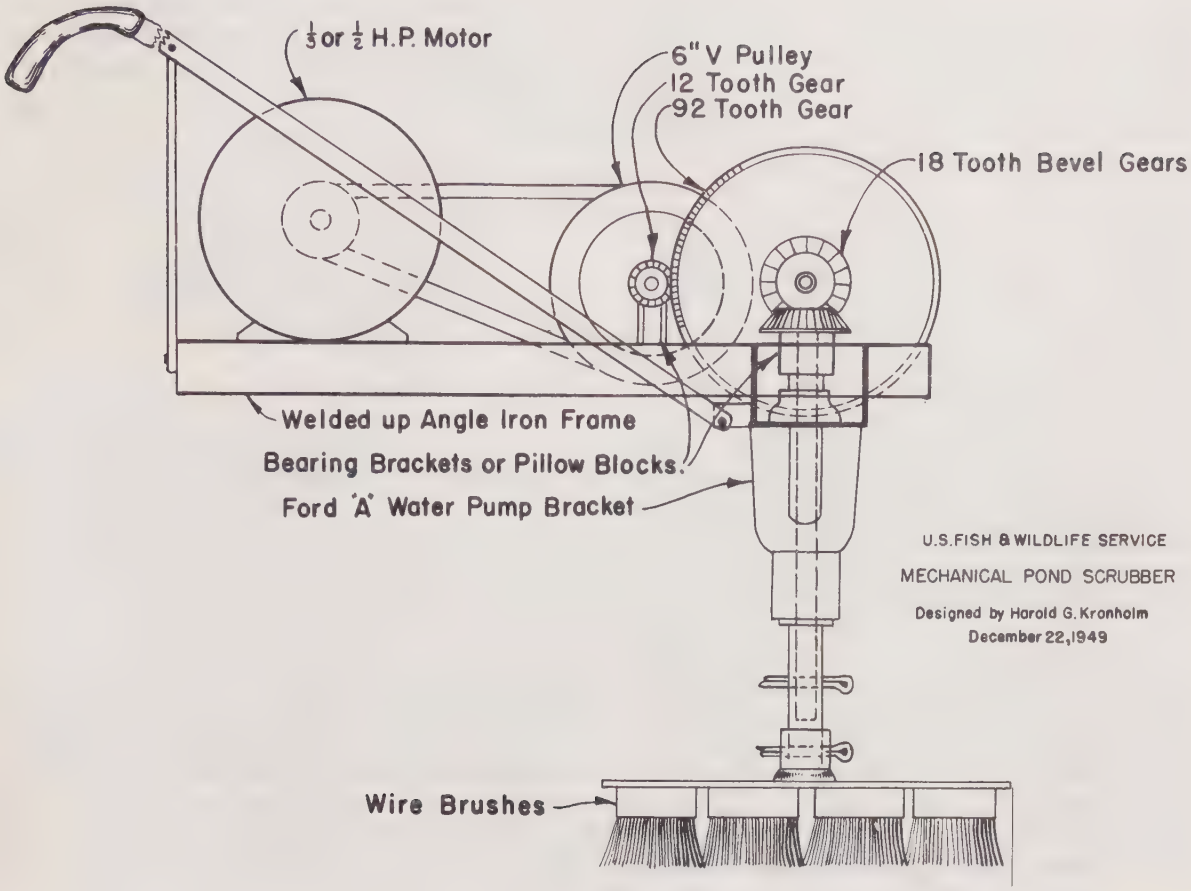
The photographs and drawings show the main points of construction and operation. A few minor details not included in the drawings are apparent in the photographs. For instance, a U-shaped handle is welded to the front of the machine to facilitate movement over obstacles and from pond to pond. Also, a quick-change motor mount is not shown.

The frame is made by welding the two short pieces of strap iron to the inside angles on the ends of the long pieces of angle iron to form an oblong frame, 22 inches long by 5 inches wide. The short piece of angle iron is welded across the middle of the frame to take up the twist strain.

The position of the bearing brackets, or pillow blocks, which support the pulley shaft and main horizontal drive shaft, is shown in the drawings. These brackets can be welded on the frame or bolted in place if they are made of cast material.

The L-shaped brackets, which hold the vertical-shaft assemblies, are formed and welded from light material and attached to the sides of the main frame by welding. These brackets support the water-pump brackets in a vertical position. The Ford water-pump brackets were used because they provide good bearings and support for the brush-stem shafts. They are bolted to the outer ends of the L brackets in such a way that the distance between the centers of the vertical shafts is 12½ inches. These shaft centers are in line with the center of the main drive shaft. The bevel gears are pinned to the upper end of the vertical shafts and to each end of the drive shaft.

The brush stems are made of ½-inch galvanized water pipe, and the lengths are cut to suit pond conditions. When filled with water, small Foster-Lucas ponds require 28-inch stems; 4-inch stems are sufficient for empty or nearly dry ponds. The stems, reamed out to 5/8 inch at the top to fit the shaft stubs on the



machine, are fastened to the stubs with large cotter keys. Cotter keys are also used on the lower end for attaching the brush plates.

The shaft stubs extend 4 inches below the machine. The brush stems, each with a ¼-inch hole drilled 2 inches from the end for the cotter key, are reamed out 4 inches to receive the stubs.

Handles for the machine are made from ½-inch galvanized water pipe. A cross bar and a V-shaped brace are welded to the handles and hold them together. The cross bar is made of ½-inch steel tubing; the V brace is made of the same material or of 3/8-inch rod. Two lugs welded to the L brackets of the machine form the point of attachment for the lower ends of the handles, and the brace is bolted to the frame just behind the motor mount.

The gears used in the machine were salvaged from an ancient washing-machine, and might not easily be duplicated, but a pulley arrangement might well be substituted for the pinion and drive gear. The object is to reduce the speed so that the brushes rotate at about 60 revolutions per minute. The bevel gears change the direction of motion from horizontal to vertical and also produce the desired clockwise and counter-clockwise rotation of the two brush units.

When long brush stems are used, it is necessary to provide a spreader between the brushes. The spreader, which slips down over the brush stems, is made by welding a short piece of tubing on each end of a 12½-inch piece of 3/4-inch strap iron.

The rotary brushes are made by fastening four deck or scrub brushes--spaced to provide for expansion--to each iron disk with wood screws. The disks are cut from 14-gauge sheet iron, 12 inches in diameter. A 1½-inch piece of steel tubing is welded to the center of each

disk and drilled for cotter-key attachment to the brush stem. The tubing is large enough to provide for a rubber bushing between it and the stem, making a loose universal-joint effect.

A 1/2- or 1/3-horsepower electric motor is used for the power supply, but a gas engine of the lawnmower type would also seem practical.

Persistence pays off even in the fish world. Sea lampreys halted by weirs or taken in traps have shown phenomenal success in finding and passing through the smallest of apertures, thanks to this quality of persistence. The tendency to prod and explore ceaselessly along all barriers requires that great care be exercised in the construction and maintenance of weirs, traps, and holding pens for the sea lamprey.

Eighteen migrating adult sea lampreys were placed in the lower of two compartments of a live-crate that measured 3 feet by 3 feet by 6 feet and was made of ½-inch mesh hardware cloth on a light wooden frame. The depth of water within the live-crate was approximately 20 inches. A small hole, 1 inch in diameter, was made in the center of the hardware-cloth partition between the two compartments. Within 4 hours, 16 of the sea lampreys had found and passed through this hole into the upstream half of the live-crate.

Prior to the construction of a permanent station at Yellowstone Park in 1912, fish-cultural operations were conducted with some difficulty. Living in tents and later in a small cabin, the men had only open troughs set on the ground along the creeks. The problem was to hold the black-spotted trout eggs until they reached the eyed stage. It must have kept the fish-culturists busy--collecting, picking, and caring for the eggs during the day, and driving the bears away from the troughs during the night.

COMMENTS

STATE OF WASHINGTON
The Department of Game
509 Fairview Avenue North
Seattle 9
February 12, 1951

The Editor
THE PROGRESSIVE FISH-CULTURIST
Fish and Wildlife Service
Interior Building
Washington, D. C.

Dear Sir:

In your October 1947 (Vol. 9, No. 4) issue of THE PROGRESSIVE FISH-CULTURIST you had an article, "The Control of Algal Growths in Hatchery Ponds and Raceways" by Elmer F. Herman and Wendel Anderson of the Wisconsin Department of Conservation. The Washington Game Department was enthused over the findings described and made a trial at one of its trout hatcheries, Puyallup Hatchery. However, the results were not met with any great enthusiasm, as no trout were able to survive in the treated pond. For the information and word of warning to all interested persons, following is a brief description of our results.

As recommended in the aforementioned article, copper yacht paint manufactured by the Pettit Paint Company, Belleville, New Jersey, was purchased and applied to a thoroughly cleaned and dried cement pond. This pond was of a circular type and 40 feet in diameter. Four and one-half gallons of paint were required to brush it on all the inner surfaces of the pond. After 48 hours, the pond was filled with water and rainbow trout about 750 to the pound (47 to the ounce) were placed in the pond. Within a few hours all the fish were dead. We then let the pond set for eight days with the water on to flush it out thoroughly, but the trout still would not survive. The pond was then drained and allowed to set in the hot summer sun for several days in hopes that the paint would become thoroughly "set." Upon filling with water and again allowing the water to flush the pond for several days, trout still continued to die. One hundred percent mortality was experienced in all cases. Larger fingerling were also tested, but they, too, succumbed.

The pond was then scrubbed with wire brushes, flushed, and dried successively for many weeks but to no avail. Finally, in order to get this badly needed pond back in production, it was treated with concentrated nitric acid to dissolve the paint, particularly the copper base. Upon flushing and filling, no mortality was experienced.

For those interested, following are some of the chemical conditions of the water at Puyallup Hatchery: temperature, 48° F.; pH, 6.8; total solids, 102 p.p.m.; total hardness, 48 p.p.m.; methyl orange alkalinity, 24 p.p.m.; calcium, 10.6 p.p.m.; magnesium, 5.3 p.p.m.; sulfate, 3.7 p.p.m.; and chloride, 2.5 p.p.m.

From our experience we do not recommend the indiscriminate use of copper paints for the control of algae in trout ponds.

Very truly yours,

THE DEPARTMENT OF GAME
By /s/
F. H. Dettmer
Aquatic Chemist

PUBLICATIONS

REVIEW

I O W A F I S H A N D F I S H I N G

James R. Harlan and Everett B. Speaker

Iowa State Conservation Commission, Des Moines, Iowa, 1951.
237 pp., illustrated in color and in black and white. $2.

Some of my earliest childhood memories include rainbow-hued pictures of fishing in Morgan Creek, a minor tributary of the Cedar River in Linn County, Iowa. Sun-dappled shadows on cool water, the drowsy hum of insects during a warm forenoon, the metallic glance of darting dragonflies, the thrill of a tugging line, and, above all, my boyish pride in a string of shining fish are still fresh in my memory album.

It was with pleasant anticipation, therefore, that I undertook the examination of Mr. Harlan and Mr. Speaker's book on Iowa fish and fishing, and I was not disappointed when I began turning the pages and reading sections here and there. First I examined and admired the magnificent color plates and the many black-and-white illustrations of fish. Then I read some of the delightful and informative little essays on angling. Next I turned back to the table of contents and found that, in addition to providing much real entertainment and pleasure, the book is a storehouse of knowledge for anyone interested in fish and fishing in the great Middle West.

Chapter 1 reveals the rather surprising extent and variety of Iowa's fishing waters, including some 50 lakes (conveniently keyed to indicate their comparative value for fishing), the rivers with their principal tributaries, the more permanent oxbow lakes, and some 40 trout streams. Artificial lakes and reservoirs where public fishing is permitted are also listed. Chapter 2 is a brief but readable introduction to fishes, and chapters 3 to 13 include condensed descriptions of all the fishes known to occur in Iowa, arranged according to their natural family relationship. Chapter 14 deals with miscellaneous fishes representing several families.

The plan of presentation of these fish descriptions gives first the preferred common name, then the scientific name of the species, followed by other names in common use, the status of the species in Iowa, a condensed description (with reference to an illustration, if included), the food habits, life history, and the significance or angling value for each species.

Chapter 15 is an uncommonly readable and competent description of some common fish foods, especially insects and a few crustaceans. This account is made readily intelligible to the angler by liberal use of line drawings.

The last numbered chapter (16) of the book consists of a series of essays on angling for channel catfish, largemouth bass, panfish, smallmouth bass, carp, trout, bullhead, and walleyes. For the nontechnical reader, this chapter alone is worth the price of the book.

Following the numbered chapters is a section of more technical interest--a check-list of the fishes of Iowa, and keys for their identification, contributed by Dr. Reeve M. Bailey of the University of Michigan. Fish taxonomists doubtless will disagree with nomenclature and classification by such a competent authority as Dr. Bailey, for such is their nature, but for all the rest of us, and particularly those who wish to delve into zoology a little further than the average angler, the check-list and the keys for identification will provide very welcome assistance. Dr. Bailey's keys are notable not only because of their simplicity but also because of their inclusion of a number of clear line drawings either of the external form of a typical representative of each family or of diagnostic features of structure. Especially helpful are drawings such as that showing the difference between spines and simple and branched rays and indicating which specific rays or compound rays are counted in the fin-ray formulas. The keys are supplemented by an adequate glossary of terms.

The text of the main part of the book is followed by a list of literature, as is also the check-list and key section. There is no index, but the table of contents is presented in such detail as to provide an adequate substitute. Sixty-six species are illustrated by half-tone reproductions of photographs on glossy paper. The book is attractively bound.

The type is rather small, and some might be critical of the job of book making, for the frontispiece has already come unstuck in my copy. These are trivial criticisms, however, and do not detract from the credit which is due the authors and their several collaborators in presenting an excellent publication.

Elmer Higgins.

CLEARING HOUSE

Survey of the Columbia River and its tributaries - Part 6.--Z. E. Parkhurst.
Spec. Sci. Rept., Fisheries, No. 39. 58 pp. Oct. 1950. (processed)

Survey of the Columbia River and its tributaries - Part 7.--Z. E. Parkhurst.
Spec. Sci. Rept., Fisheries, No. 40. 95 pp. Nov. 1950. (processed)

Natural history of the sea lamprey (Petromyzon marinus) in Michigan.-- V. C. Applegate.
Spec. Sci. Rept., Fisheries, No. 55. 237 pp. Dec. 1950. (processed)

Survey of the Columbia River and its tributaries - Part 8.--Z. E. Parkhurst.
Spec. Sci. Rept., Fisheries, No. 57. 19 pp. Dec. 1950. (processed)

A fishery survey of southern coastal waters.--R. J. Buller.
Spec. Sci. Rept., Fisheries, No. 58. 21 pp. Feb. 1951. (processed)
Fish and Wildlife Service, Interior Building, Washington 25, D. C.

The nutrition of trout: Cortland hatchery report No. 18 for the year 1949.--A. M. Phillips, Jr., D. R. Brockway, Maurice Bryant, et al.
Fish. Res. Bull. 13. 30 pp. 1951. 10 cents.
New York Conservation Department, Albany 7, New York.

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